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Sky and TELESCOPE

NEW METEORITE CRATERS?

A MAGNETIC ANOMALY discovered at the Ungava crater in northern Quebec has been offered as evidence that a meteorite crashed into the Canadian tundra centuries ago, leaving what is now a circular water-filled scar, pictured here and on the front cover. Dr. V. B. Meen, director of the Royal Ontario Museum of Geology and Mineralogy, recently reported these findings of a National Geographic Society-Royal Ontario Museum expedition to the crater in July and August, 1951.

On his first visit to the crater in 1950, Dr. Meen tentatively identified it as of meteoritic origin. Three weeks work this year with mine detectors and power magnets dragged over the ground produced nothing conclusive, but 48 hours before their flight back to civilization the expedition's scientists discovered a magnetic anomaly along the eastern portion of the crater rim. Such a disturbance of the earth's normal magnetic field may be interpreted as indicating the presence of an underground metal-bearing mass. It is believed to constitute proof of iron-bearing meteoritic material, in view of the otherwise granitic nature of the region.

The only material other than granite found at the crater in 1950 by Dr. Meen were fragments of diabase, a well-known igneous intrusive rock. No diabase was seen in place, and Dr. Meen concluded that the fragments were fractured from a vein near the south rim by the supposed blast of the meteorite.

Although the crater had been found on Royal Canadian Air Force photographs made several years ago, it was not investigated geologically until Fred W. Chubb, a prospector, pointed it out to Dr. Meen on an aerial photograph. Chubb had hoped that it was of volcanic origin, as a possible source of diamonds, but the 1950 expedition, described by Dr. Meen in the *Journal* of the Royal Astronomical Society of Canada, XLIV, 5, September-October, 1950, determined that neither volcanic nor glacial action could explain this unusual round formation.

The Chubb crater, as Dr. Meen proposes it be called, is located in the remote and barren region between Hudson and Ungava bays, at latitude 61° 17′ north and longitude 73° 40′ west. Two miles in diameter, the crater remains filled with ice through the short summer, but soundings made this year show the water to be 850 feet deep, making this one of Canada's deepest lakes. The rocky rim, sloping at an angle of 45 degrees, reaches a maximum height, on the northeast side, of 500 feet above the lake surface. Thus, the total depth of the crater is

(Continued on page 9)

Sky and TELESCOPE

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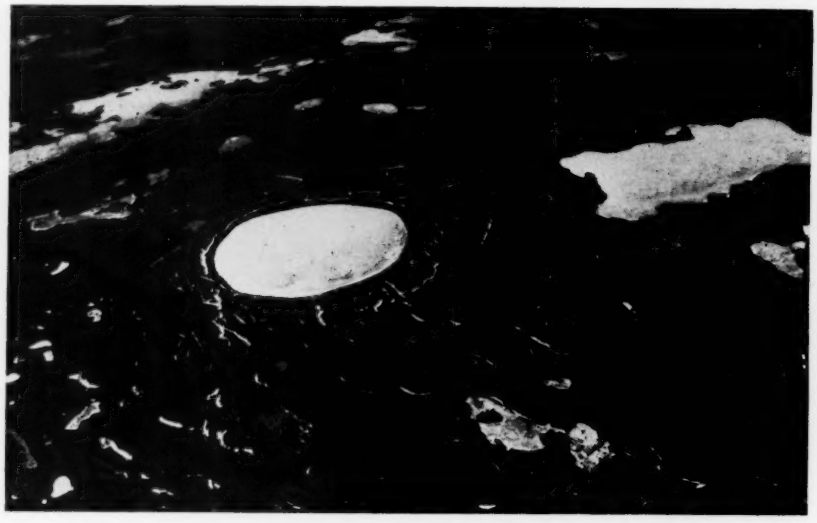

Ice-filled Chubb Crater and Museum Lake (names proposed by Dr. Meen) present sharp contrasts in this aerial photograph from 20,000 feet, looking approximately westward. Note the radial rifts outside the crater. Royal Canadian Air Force photograph.

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NOVEMBER, 1951

COVER: The two-mile-wide crater in the Ungava region of northern Quebec, Canada, looking approximately northeast. The highest part of the rim is at the right. This crater may have been caused by the fall of a large meteorite. Photograph taken by the Royal Canadian Air Force, July 20, 1948.

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BACK COVER: Hydrogen spectroheliograms showing the development of the remarkable flare on the edge of the sun, May 8, 1951, as observed by Dr. Helen W. Dodson at the McMath-Hulbert Observatory. All were taken shortly after 15:00 UT, the top left at 15:00.7; top right at 15:03.5; those following at 05.2, 05.7, 06.3, 07.4, 10.0, and 11.9. The series thus shows changes in only 11.2 minutes. The onset of the flare coincided with a sudden ionospheric disturbance (SID) in the earth's atmosphere. This series of pictures will appear as the frontispiece of a book on astrophysics by Dr. L. H. Aller. University of Michigan Observatory photograph. (See page 11.)

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The school of Galileo: an encaustic on the wall of the faculty of science room, University of Padua, executed by Ferruccio Ferrazzi in 1942-43.

GALILEO IN PADUA

BY RUFUS SUTER

PADUA, the seat of the second oldest university in Italy, was the home of Galileo for 18 years. There he constructed the original astronomical telescope in a sliding tube and on a base. There he made the first telescopic observations of the heavens in history.

Galileo came to Padua as a teacher at the university one century after Columbus sighted the New World. The explorations of the astronomer had as invigorating an effect upon the mind of man as did the voyages of the sailor. Yet Galileo's busy life in Padua has left few evidences in the form of relics or memorials, when compared with Florence, the other city where he spent many years. (See the author's "Some Relics of Galileo in Florence," *Scientific Monthly,* October, 1951, page 229.)

If we visit Padua we may be disappointed in this respect, though the medieval charm of the old part of the city is certain to fascinate us. We will be delighted to find a Via Galileo Galilei roofed at one end by a stone portico, as are several other sidewalks in the town, giving the impression of cloisters in an ancient cathedral, especially somber at night.

At No. 31 is an edifice with a massive red stone front rising abruptly from the pavement as do the houses in Baltimore. This, at present the residence of the Conte Francesco Ferri, was formerly the house of Galileo, or rather is on the site of Galileo's home since much of it has been rebuilt. This of all places in Padua would serve most appropriately as a memorial to the father of telescopic astronomy, but it does not contain even an inscription.

The courtyard, overgrown with weeds, is the spot where according to local tradition Galileo discovered the first four of Jupiter's 11 moons, or, as he called them, "Medicean stars," in honor of Cosimo II, grand duke of Tuscany, who was later to be his employer. There he probably made all the observations recorded in his *Sidereus nuncius* (Venice, 1610). Among them was the discovery elementary to us now but really a primary observational fact in the birth of the new astronomy: that the planets when viewed through the telescope present disks, while the stars remain points of light. The stars practically still remain points of light even when seen through the 200-inch giant on Palomar Mountain. There was another elemental discovery: that star clusters such as the Pleiades and the Beehive show more stars through the telescope than to the unaided eye. The clouds of the Milky Way resolve into countless stars. Columbus was the first to see the New World, but Galileo was the first to behold tens of thousands of suns new to the human race.

In this same courtyard the moon disclosed itself a lesser earth, with mountains and valleys springing up to meet the eye as vividly as the features on a relief map. Two other telescopic discoveries, not recorded in the *Sidereus nuncius* but covertly announced by anagrams in letters, were probably made there: the phases of Venus and the tri-form figure of Saturn. Galileo's resolving power was not sufficient clearly to show the rings.

The father of telescopic astronomy has sometimes been criticized for not showing the observational genius of Sir William Herschel in the next century. Yet his spadework was by no means paltry. The value of several of his discoveries, outside of their intrinsic interest, is that they argue analogically for the Copernican teachings that the earth spins on its axis and swings round the sun in an orbit. And in their phases is evidence better than analogical that Venus and Mercury revolve round Old Sol. The maestro saw these implications clearly; they are the basis for his argument in the *Dialogo sopra i due massimi sistemi del mondo* (1632) published many years later in Florence.

The residence at what is now No. 31 Via Galileo Galilei is historically important not only for its courtyard but also for the workshop which it once housed. Besides being the father of telescopic astronomy and one of the founders of modern physics, Galileo was an inventor and perfecter of the inventions of others, as prolific as Edison. In this workshop with the aid of an expert workman, Antonio Mazzoleni, several early telescopes, if not the original one, were made. Also various kinds of drafting instruments were manufactured, as well as hydrostatic balances, air thermometers, magnets, armatures, and mariner's compasses. Galileo's most successful invention from the financial point of view was the sector, or, as he called it, the geometrical and military compass. Mazzoleni manufactured this instrument in copper and silver by the hundreds in response to a wide demand from various countries of Europe. A press was installed to set up the type for a tract on its operation. Several copies of this essay, *Le Operazioni del Compasso Geometrico e Militare* (Padua, 1606), are extant in Italian libraries. The work is dedicated to the same grand duke of Tuscany for whom the four Medicean stars were named.

The university at which Galileo taught and to which he was appointed professor for life after he had presented a telescope (magnifying nine times!) to Leonardo Donato, the doge of Venice, was and is still called the Bo (Ox). This venerable institution is so named because in 1493 various schools, already centuries old, were united in a hotel "At the sign of the Ox." The Venetian authorities had the power to invest Galileo at this Paduan university because in his day Padua was under the rule of Venice, and indeed had been for six generations. The two cities are 25 miles apart.

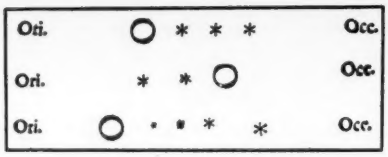
The Bo has two Galilean relics. One is Galileo's fifth lumbar vertebra. This anatomical specimen was removed from his remains on March 12, 1737, in Florence, when his body was at last transferred from its original resting place to the mausoleum in the hallowed interior of the Church of Santa Croce, where he lies to this day. If the American visitor is astonished at the gruesome exhibit he should consider that the Italians, who have made a practice of preserving parts of the bodies of countless great souls of religion through the ages, have a different feeling in the matter. Such

relics for them evoke reverence rather than shock.

The other relic is Galileo's professorial chair or cathedra. It is now in a hall called the Sala dei Quaranta from the number of portraits on its walls by a recent artist, Giacomo dal Forno, depicting foreigners who studied at the Bo in years gone by. The cathedra is a wooden structure resembling a pulpit with steps leading up to it. Age has left it rickety and paintless. It was almost destroyed by fire in the last century. On top sets a bust of Galileo with a peculiarly impish cast to his face not found in other likenesses.

Among the portraits of the Sala dei Quaranta is one of the English discoverer of the circulation of the blood, William Harvey. This doctor, whose career in physiology was as epoch-making as that of Galileo in astronomy and physics, attended the Bo between 1590 and 1602. He was a pupil of the university's great anatomist Geronimo Fabrizio (H. Fabricius), called Acquapendente after his birthplace, and doubtless often stood in Acquapendente's torch-lit anatomical theater, the first in Europe, still preserved at the university as a gigantic museum piece. As far as chronological possibilities are concerned, Harvey could have known Galileo.

This matter of friends in Padua is worthy of a moment's reflection. Galileo had many bitter enemies, especially in later life, and it is pleasant to think of him as for a while surrounded by sympathetic friends. Two men in particular enjoyed his esteem, both of whom he met in Venice at the home of a rich patrician who liked to entertain scientists. One of these friends, Giovanfrancesco Sagredo, will be familiar to students of the aforementioned *Dialogo* and the *Dialoghi delle nuove scienze* (Leyden, 1638), as the interlocutor who represents the intelligent man of affairs. Students may, however, be astonished that Sagredo was not a figment of Galileo's imagination but a real man. He was a much-traveled Venetian diplomat interested in experimentation with the air thermometer and the armed magnet. He is known in another connection than through Galileo, for he was a correspondent of Queen Elizabeth's physician, William Gilbert, who founded three sciences, geomagnetism, magnetism, and electrostatics, proceeding by the same technique of controlled experiment and observation that Galileo afterward used.



In the year 1610, on successive observing nights, Galileo drew these first pictures ever made of the positions of Jupiter's satellites.

The other friend, Paolo Sarpi, was typical of the genius of the Renaissance in the breadth of his interests. He was an astronomer whom Galileo called "my father and my master," a mathematician, an experimenter in physics, a physiologist, a linguist, the unorthodox historian of the Council of Trent, a writer of propagandist political tracts, and an ardent Venetian patriot. As an astronomical observer he drew one of the first maps of the moon. But his most remarkable observations were in physiology rather than astronomy. He is credited with the discovery of the contractility of the iris of the human eye. He seems to have contributed to the idea that the veins are equipped with valves. Italians like to point out that this latter achievement, communicated to Acquapendente, was instrumental in steering the Paduan anatomist's pupil, Harvey, to full knowledge of the circulation of the blood. Sarpi's fiery zeal for Venetian independence caused him to run afoul of the temporal claims of the same Borghese pope, Paul V, who first warned Galileo about the danger to religion of the teaching that the earth moves.

These two liberal-minded Venetians, Sagredo and Sarpi, encouraged Galileo in his experimental and observational labors, and collaborated with him. Sarpi, being himself a mathematician, could appreciate the inestimable importance of expressing results in mathematical formulae. It is conceivable also that Sarpi's antiecclesiastical zeal may have stiffened Galileo's resistance to churchly antagonism against the teaching that the earth moves — a resistance which, however, melted in the face of the Roman Inquisition.

Galileo's domestic life in Padua deserves notice. At the residence at No. 31 Via Galileo Galilei, he had his open-air observatory and his workshop and he kept a boardinghouse and dormitory for his pupils. Here passed his public life, calm, ordered, intellectual, full of contributions to science. But in another part of town he maintained a second home where his private domestic life followed a less even course. He lived with a Venetian woman, Marina Gamba, who is said to have had little sympathy for his learned pursuits. To aggravate the uneasiness of his domesticity, poor relations constantly harassed him. Marina presented him with three children. His favorite, Virginia, was born in Padua on August 13, 1600. Afterwards she took the veil and lived out her short life at the Convent of San Matteo, now a monastery, at Arcetri in the suburbs of Florence. She is known by her name in religion, Maria Celeste. This girl, of an exceptionally faithful and compassionate nature, has an amiable place in history for her sympathetic letters to her father during his troubles with the Inquisition.

Perhaps it is no exaggeration to say that Galileo's happiest years were spent in Padua, although at the time he did not appreciate this. If he had remained in the university town he might never have fallen into the hands of the Inquisition, for, as has been said, Padua was under the rule of Venice, and the Queen of the Adriatic was jealous of her independence of the Eternal City. But Galileo wanted honor, money, and the excitement and glamour of a court. His advances to the grand duke of Tuscany at length bore fruit. In the fall of 1610 he left the 18-year-long scene of his labors and returned to his ancestral home, Florence, as philosopher and mathematician extraordinary to the court of Cosimo II.

An indication of the relatively low resolving power of Galileo's telescope is given by such drawings as this one of the moon, reproduced from his publication, "Starry Messenger."

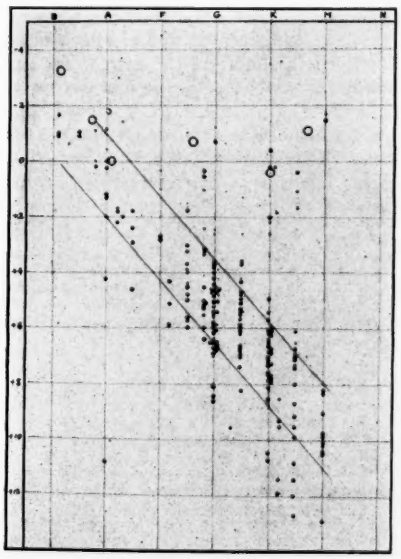
Galileo observed sunspots moving across the disk of the sun, drawing them as reproduced here. He discovered the rotation of the sun, revealed by the motions of the spots.

COLOR - LUMINOSITY ARRAYS

OLIN J. EGGEN, *Lick Observatory, University of California*

ONE of the most important single contributions to astrophysics was made by Henry Norris Russell to what was, in point of attendance, a somewhat unsuccessful meeting of the Astronomical and Astrophysical Society of America, as the American Astronomical Society was once named. On December 30, 1913, at the 16th meeting of the society at Atlanta, Ga., a joint session was held with Section A of the American Association for the Advancement of Science. There Russell presented the diagram which has become associated with his name. His original article, published in *Popular Astronomy,* Volume 22, is still exciting reading for professionals and amateurs alike.

Nearly contemporary work by the European astronomer, Ejnar Hertzsprung, so closely paralleled Russell's diagram that it is now known as the Russell-Hertzsprung (R-H) diagram [or Hertzsprung-Russell diagram, according to one's preference]. The accompanying illustration is of Russell's first chart in his paper, containing some 300 stars for which direct measures of parallax were available in the spring of 1913, when the diagram was originally constructed. The small dots represent poor parallaxes; the small open circles, single good parallaxes; the solid black dots, the means of two or more good parallaxes for the same star. The large open circles in the upper part of the diagram represent mean results for numerous bright stars of small proper motion (about 120 altogether) whose observed parallaxes then hardly exceeded their probable errors. Other similar diagrams, such as for stars in moving clusters, were also presented by Russell to substantiate this spectrum-luminosity arrangement.



The original basic diagram presented by Henry Norris Russell in 1913, based on stars for which direct trigonometric distance measurements were then available. The abscissae are spectral classes; the ordinates are absolute magnitudes. Reproduced from "Popular Astronomy."

Some of the astronomers in attendance at the Atlanta meeting of the Astronomical and Astrophysical Society of America, December, 1913. Left to right: front row, Comstock, E. Pickering, Fox; middle row, Slocum, Moulton, Russell; back row, Barton, Peek, Eichelberger, Rigge, Emerson. Reproduced from "Popular Astronomy."

In working a jigsaw puzzle, it is helpful first to collect all pieces of the same color or those having a straight edge on one side, that is, to arrange the pieces according to some systematic scheme. Since, except for meteorites, direct physical contact with celestial objects is not possible, many astrophysical problems must be attacked with the hope that some regularity in form, or in progressive development, will be revealed by systematic classification of the observable quantities. The Russell - Hertzsprung diagram is an excellent example of a scheme in which the measurable properties of stars, the real brightnesses or luminosities, and the temperatures as indicated by the spectral types, are correlated with one another.

The immediate effect of such a correlation was the discovery of two different kinds of stars, called *giants* and *dwarfs* by Hertzsprung. These make different patterns in the R-H diagram, the dwarfs forming a diagonal band running from the blue, hot, and bright stars to the red, cool, and faint stars, and the giants forming a nearly horizontal band which shows little change in brightness with changing temperature. The R-H diagram resembles an inverted 7 or, perhaps, an incomplete Y. The width of the band formed by the dwarfs is such that two stars, of the same temperature, one at the top and the other at the bottom of the band, may differ in real brightness by as much as a factor of 2.5, although in Russell's early diagrams this difference was more than twice as great, owing to uncertainties in the observational data at that time.

Since the R-H diagram was first presented, most theories of stellar structure and stellar evolution either have been directly based upon it or have accepted it as a fundamental relationship between luminosity and temperature. Even the fact that the relationship is not one to one, that is, the diagram consists of bands and not of lines, has been used in many of these theories.

What makes Russell's discovery doubly remarkable is the fact that two serious observational difficulties tend to mask the true relationship between temperature and luminosity. The first is the determination of the real brightness, or luminosity, of a star. Since the stars are not all at the same distance from us, the difference in apparent brightness of two stars is caused not only by a difference in their distance but also by a difference in their real brightnesses, and the distance effect has to be removed in order to compare their luminosities.

As the most obvious feature of a star is its light, it would be reasonable to expect that a measure of the amount of this light would be an accurately determined datum. In general this is true but, unfortunately, it is not true enough; we do not know the brightnesses of many stars to an accuracy better than 10 to 20 per cent. The main reason for this uncertainty lies in the two devices most commonly used to measure the amount of starlight: the eye and the photographic plate. No two sets of eyes are quite the same, so that brightness estimates by different observers are not directly comparable. Also, the eye is not sensitive enough to small changes in light to yield results of the highest accuracy. The photographic plate is plagued by most of the defects of the eye and possesses many unique shortcomings of its own. Thus, although the

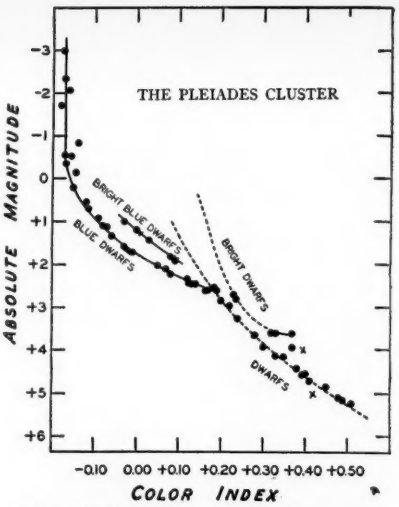
brightness measures made photographically are more accurate than those made by eye, they still fall short of providing the highest accuracy. When the uncertainty in the apparent brightness of a star is added to the still greater uncertainty in the distance of the star, the resulting intrinsic luminosity may be quite inaccurate.

The second major source of error in the R-H diagram is that the temperature is not used directly but is inferred from the spectral type of the star. It was found many years ago at Harvard Observatory that, although the spectra of different stars may differ widely, they form a fairly regular progression in the appearance and intensity of various spectral features. The Harvard observers noticed several points in the progression where certain features in the spectrum were at their weakest or strongest, and assigned arbitrary letters to these interruptions. Thus, the hottest stars are termed type *O*, and then the sequence passes through types *B, A, F, G, K,* and *M*, as the temperatures become lower. These letters, or spectral types, are used in the R-H diagram as expressions of the temperatures of the stars.

There are two difficulties with this procedure. First, the spectral types, although indispensable in astrophysics, are not sufficiently precise for the highest accuracy, since they do not represent a smooth, or even uniform, progression but rather a finite set of points arranged on an arbitrary scale. As a result, a certain amount of "lumpiness" is introduced into the diagram. Second, the spectra of the stars are often very complex, and it is not always possible to assign a unique letter for the spectral type.

In 1906, Joel Stebbins began the first experiments in this country with a new technique in stellar brightness measurements — photoelectric photometry — in which a photocell was substituted for the eye or the photographic plate as a light receiver. The photocell is a transducer, that is, it changes one form of energy to another. It works on the principle that if starlight falls on a certain type of coated surface, electricity is generated, and the more light, the more electricity, so that a measure of the generated electricity is also a measure of the brightness of a star. Fortunately, most of the difficulties which in photometry plague the use of the eye and the photographic plate have not been encountered, as yet, in the use of the photocell. One initial drawback, however, in applying the new technique to astronomy was that only the brightest stars could be measured, since the sensitivity of the photocell to faint light was rather limited. This limitation has been largely overcome in recent years by the development by A. E. Whitford, of Washburn Observatory, of the thermionic amplifier which permits the electricity generated by the photocell to be amplified before measurement, and by the application of a supersensitive photocell which has been adapted to astronomical photometry by Whitford and Gerald Kron, of Lick Observatory. This sensitive photocell, called a photomultiplier, was developed by the Radio Corporation of America (*Sky and Telescope,* October, 1947, page 7), and owes its success principally to the discovery of the unusually sensitive antimony-cesium photosurface by the German physicists Gorhlich and Meyer in 1938.

With the use of this sensitive light receiver we are not only able substantially to improve the accuracy of the brightness co-ordinate of the R-H diagram, but we also may circumvent the use of the spectral types as the temperature co-ordinate. Instead, we can measure the color of starlight by observing the difference in the amount of light passed by two different color filters. These filters are merely pieces of colored glass of optical quality, and of the two usually used with a photomultiplier one lets through only blue light, the other only yellow. To be convinced that a color sequence is also a temperature sequence you have only to watch a metal rod being heated in a forge: it becomes first a dull red, then a bright cherry color, orange, and finally white hot.

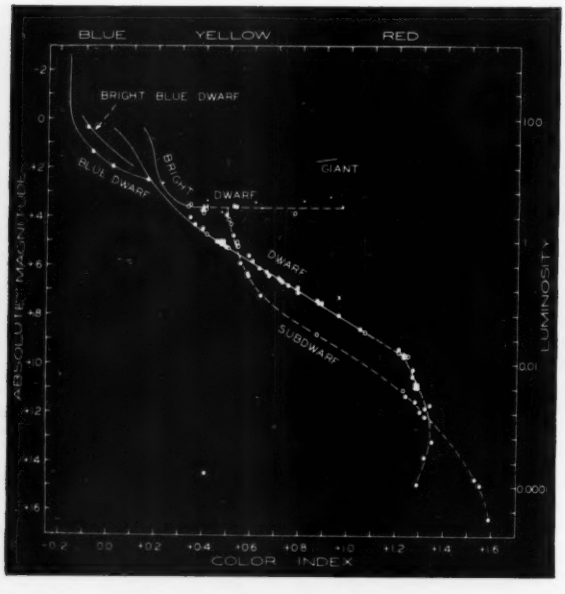


The Pleiades color-luminosity array. One cross indicates a double star, the other a probable non-member. The solid lines mark sequences added by the Pleiades to those of the Hyades (dashed lines).

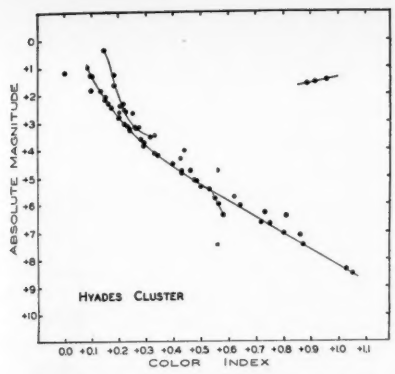
With accurate photoelectric measurements of the apparent brightnesses of the stars and the smooth sequence of colors, we can reduce much of the uncertainty involved in the R-H diagram. Yet for many stars we have no precise distances, and these are necessary to convert apparent brightnesses to luminosities. This uncertainty can be largely overcome by observing only stars in clusters — groups of stars all moving together in the same direction and at the same rate. Familiar examples are the Pleiades and the Hyades. Since the stars of a cluster are all at nearly the same distance from the earth, the difference in apparent brightness of two cluster stars is also equal to the difference in their real brightness, without being confounded with the distance effect.

To summarize, then, with the photoelectrically determined colors, which are a measure of temperature, and apparent brightnesses of the stars in a cluster such as the Pleiades, we are able to redraw the R-H diagram with a large gain in accuracy. Since for these diagrams we use color instead of spectral types, they are referred to as color-luminosity arrays.

The accompanying diagrams show the color-luminosity arrays for some members of the Hyades, Pleiades, and Ursa Major clusters. The most obvious fea-



The color-luminosity array for stars within 45 light-years of the sun. Solid dots are those nearer than 10 parsecs; open dots are stars between 10 and 14 parsecs. A double star is marked with a cross. Lick Observatory diagram.



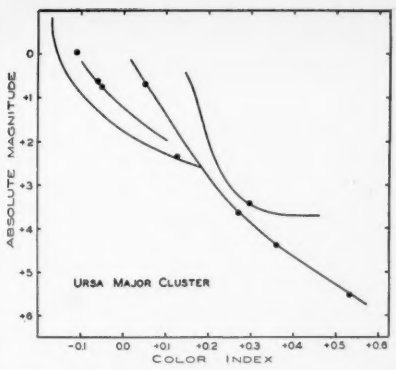
The Hyades cluster array, in which open circles indicate double stars. Note the giant sequence in the upper right of the chart.

ture of these arrays is that the broad-band structure seen in the general R-H diagram is resolved into a fine structure of well-defined sequences, upon which the stars fall almost like beads on a string. The names tentatively given the various sequences are admittedly cumbersome, but any attempt to systematize this nomenclature must wait until we are fairly certain that further sequences are not forthcoming. These names are shown on the color-luminosity array for some of the stars within 45 light-years of the sun.

Only the nearest stars are included in this diagram to minimize the effect on luminosities of the uncertainties in their distances. A comparison among the charts shows that the sequences populated by cluster stars are also populated by stars near the sun. Also, two of the sequences found in the cluster arrays, bright dwarf and subdwarf, are greatly extended in the array for the nearest stars. Furthermore, certain types of stars appear to be mutually excluded in the cluster arrays; for example, the Pleiades stars heavily populate the blue-dwarf sequence but leave the upper portions of the dwarf and bright-dwarf sequences bare, while the Hyades stars populate these latter two sequences but contain no blue dwarfs. Other mutually exclusive groups of stars in clusters are the giants and the blue dwarfs, as can be seen by comparing the Pleiades with the Hyades and Ursa Major clusters.

From these color-luminosity arrays, and others like them, we get a strong indication that the stars in the sun's neighborhood, which includes the clusters, populate mainly the named sequences. There are several reasons that a few individual stars may depart from these sequences. A star may be behind, or imbedded in, a patch of interstellar material, making its apparent brightness too dim. A star may be double or multiple, so that the resulting measured brightness is the sum of the light of the stars involved, and the color represents the average temperature. Some distortion of the distribution of a star's light throughout the spectrum could affect the measured color. Finally, a few stars may be exceptions to the general rules by reason of peculiar chemical composition or unnatural evolution.

We are not able to extrapolate our knowledge of stars in the vicinity of the sun to the much larger number which are located throughout the more remote sections of our galaxy. In fact, we already have indications that a type of star greatly outnumbered in space near the sun predominates in other parts of the galaxy, particularly around the galactic center. The region of the sun has been referred to, by Walter Baade, of Mount Wilson and Palomar Observatories, as the "local swimming hole," in contrast to the larger "ocean" of stars and galaxies beyond. We are, at the moment, learning to swim at home.



The manner in which the stars of the nucleus of the Ursa Major cluster fall on several of the newly defined sequences.

ED. NOTE: The author of this article is at present on leave to obtain observations at the Commonwealth Observatory at Mt. Stromlo, Australia. He is expected to return to Lick Observatory in the early part of 1952.

TERMINOLOGY TALKS

J. Hugh Pruett

Ancient Concepts

The sight of the blue dome of the night sky sprinkled thickly with stars, which seemed to move smoothly together westward, could not have failed to impress the ancient peoples. There were always scientists of a sort among them who tried to give reasonable explanations for all the observed objects and their motions.

It must have been very early that they noticed there were five objects — wanderers, they called them — which changed their positions more or less rapidly among the countless stars. These *planets* moved nightly westward with the others, but at times very definitely got ahead or fell behind. The moon moved even more noticeably, eastward, although it, too, rose in the east and set in the west every day. And it became known that the sun also backed eastward among the stars, although at a much slower rate than the moon.

The early astronomers decided that the sun, moon, and planets must be nearer to them than the sphere of the stars. Then started the eventually elaborate attempts to explain why the sun and moon slid eastward fairly regularly while the planets were at times very erratic in speed and direction.

Crystalline Spheres

Generally, it was thought that the real stars were attached to an enormous sphere that revolved once a day around our stationary earth. The more enlightened astronomers agreed that the earth was a globe, but they still considered it to have no rotation of any kind. The mighty dome of the distant stars daily did obeisance to the all-important earth by circling it.

As for the sun, moon, and planets, they were at various distances away. But there must have been something to hold them somewhat in place. For this there was proposed the system of crystalline spheres, so transparent that the light from the more distant stars passed easily through them. There were imagined seven of these spheres, huge, hollow cosmic soap bubbles, all with their centers approximately at the earth and arranged one outside the other at various distances from our globe.

To the nearest of these spheres the moon was attached, then Mercury, Venus, the sun, Mars, Jupiter, and Saturn, in that order. These inner spheres in some way were caused to move with the outermost stellar sphere, daily westward around the earth, carrying the planets with them. But the planets seemed to have minor motions of their own along their individual liquid bubble surfaces. To explain these, various systems were devised, as we shall see in our next talk.

IAU MEETING FOR 1952 IS SCHEDULED

The executive committee of the International Astronomical Union met in Paris during the second week of September, and decided to hold the next general assembly in Rome sometime in September, 1952. Dr. J. J. Nassau, of Warner and Swasey Observatory, chairman of the United States national committee of the IAU, states, "From our brief communication it appears that this plan is satisfactory to all concerned. Full details will be sent to all the members of the IAU as soon as they become available."

Amateur Astronomers

More Reports on the Annular Eclipse

LUC SECRETAN, of Washington, D. C., selected an observing site that proved to be one of the best along a generally cloudy eclipse path, Saturday morning, September 1st. Armed with a Leica camera and 17-inch Dahlmeyer anastigmat set up on the observation platform at Philpott Dam, Va., he captured the eclipse in a 70-minute series of pictures, six of which are reproduced here.

Hermine Secretan recorded times and technical data as her husband photographed the eclipse. The altitude of their observing site was 1,000 feet.

His exposure times were selected so well that they show the true annulus, in width only two per cent of the sun's diameter at mid-eclipse — an extremely narrow ring. For these six pictures, on Finopan 35-mm. film at f/32, exposures ranged from 1/40 second for the first picture to 1/100 on the last, taken just after third contact. The partial phases were shot at 1/500 or 1/1,000 second. While Mr. Secretan operated the camera, his wife recorded the time and the exposure data for each picture.

The sun rose eclipsed at 5:55 a.m. EST, a bright red sickle. Two minutes later, as it cleared the horizon, it appeared as in the first picture. Strong distortion from atmospheric refraction twisted the semicircle into part of an ellipse. Just before second contact, Mr. Secretan observed Baily's beads, and they remained visible through the annular phase of the eclipse. Then third contact came at about 6:01 a.m., between the fifth and sixth pictures. On the original negative of the fifth picture, a full ring of sunlight may be detected.

After the October story on "Eclipse Experiences" had gone to press, additional reports were received from several amateur astronomers. William H. Glenn, of New York City, describes a tantalizing fogout at Virginia Beach; he was accompanied by Professor Otto F. H. Bert, of Washington and Jefferson College. R. H. Dellett, of Chevy Chase, Md., describes his observations from Pilot Mountain as follows:

"The thunderheads on our left began to reflect a warmer light; brownish, then pink. In turn, the underneath of the clouds overhead brightened and, between two distant peaks, one red tooth of the crescent sun cut up through the dark horizon. Although it was exactly what everyone had expected to see, our high vantage point and unlimited view dramatically accentuated the grand scale of the phenomenon. The crowd was audibly impressed.

"The other cusp of the crescent appeared quickly, then the whole horseshoe, sharp, red, and easily observed. . . . The shimmering horns of the crescent lengthened upward, extended, and met instantaneously in a wavering red line over the moon. With the naked eye, the scene was impressive: Above us the clouds were brilliant coral while the valley below showed green. . . . The sun hung like a precise, slightly flattened red O. . . . Through the telescope I watched the circle break, the horns shrink and thicken, and the crescent become steady and yellow. . . . Satisfied observers began to climb back down the sunlit rocks; it had been worth the effort."

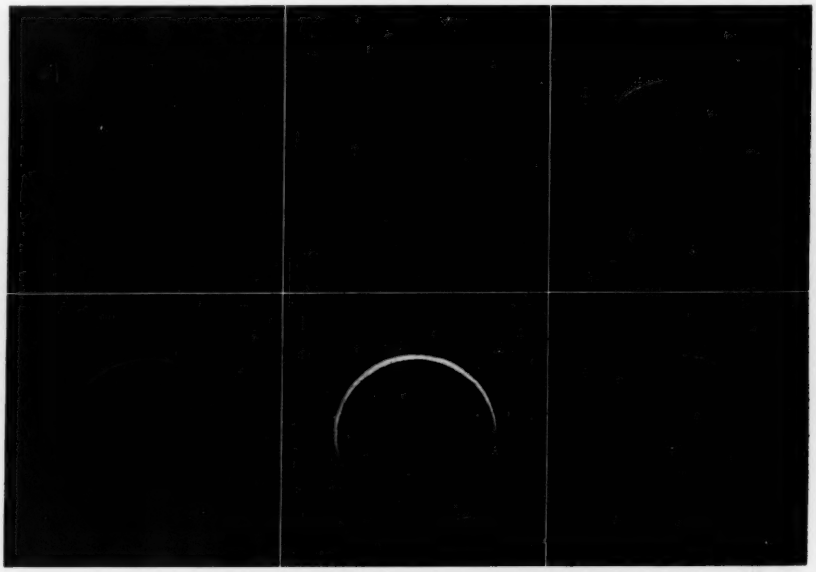
Frank B. Dinwiddie, at Nags Head, N. C., observed the phenomenon in spite of partial cloudiness. He watched the cusps rise out of the Atlantic Ocean, the sun becoming a dazzling orange galleon. At his location 74 miles from the central path, the cusps extended about three quarters of the distance around the moon at mid-eclipse. The rapidity with which the crescent shifted from below to above the moon was startling.

At Danville, Va., the rising sun presented weird effects, but J. V. Perry writes that these were followed by the clear-cut figure of the moon surrounded by a perfect "golden annulus," to the delight of the observers gathered at the Danville airport. It was noted that the eclipse did not seem to affect the birds, who were at their morning feeding grounds while the eclipse was in progress.

Luc Secretan mounted his camera with telephoto lens adjustably on a painter's easel. Note the telescopic viewfinder.

LECTURES IN BOSTON

Under the auspices of the Lowell Institute, Dr. Cecilia Payne-Gaposchkin, of Harvard Observatory, will give a series of eight illustrated lectures on "Stellar Evolution" in the lecture hall of the Boston Public Library. The lectures are free and will be held from 8:00 to 9:00 in the evening on consecutive Fridays and Tuesdays, beginning November 2nd. Further information may be obtained from the Lowell Institute, Public Library, Boston 17, Mass.



Luc Secretan's photographs were taken at (upper row, left to right) 5:57 a.m. EST; 5:58, just before second contact; 5:59½, after second contact; (lower row) 5:59¾; 6:01, just before third contact; 6:01½, just after third contact.

THIS MONTH'S MEETINGS

Buffalo, N. Y.: At the November 7th meeting of the Amateur Telescope Makers and Observers of Buffalo, Paul Stevens, chairman, Northeast region, Astronomical League, will report on the Chapel Hill convention. The meeting is at 8:00 p.m., at the Buffalo Museum of Science.

Cambridge, Mass.: "Meteors and Space Travel" is the topic of Dr. Fred L. Whipple, Harvard Observatory, speaker at the November 1st meeting of the Bond Astronomical Club, 8:00 p.m., at the observatory.

Cleveland, Ohio: The Cleveland Astronomical Society will meet at 8:00 p.m. Friday, November 16th, at the Warner and Swasey Observatory, to hear Dr. Cedric E. Hesthal, Ohio State University, speak on "Cosmic Rays and Radio Waves from Space."

Columbus, Ohio: Leon N. Zechiel will discuss "Sunlight and Starlight" before the Columbus Astronomical Society, at the McMillin Observatory, Friday, November 9th, at 8:00 p.m.

Dallas, Tex.: There will be a lecture on nebulae and clusters, illustrated by filmstrips, at the Monday, November 26th, meeting of the Texas Astronomical Society, 8:00 p.m., at the Texas Bank and Trust Company building.

Indianapolis, Ind.: A report on the Link Observatory of the University of Indiana will be given by Dr. James Cuffey to the Indiana Astronomical Society on Sunday, November 4th, at 2:15 p.m., at Cropsey Hall of the Central Library.

Madison, Wis.: Dr. G. P. Kuiper, Yerkes and McDonald Observatories, will describe "Recent Planetary Observations" at the annual banquet of the Madison Astronomical Society. This will be held on November 14th in the Memorial Union of the University of Wisconsin.

New York, N. Y.: "Astronomy Off the Deep End" is the title of a lecture by Robert R. Coles, chairman, Hayden Planetarium, to the Amateur Astronomers Association, on Wednesday, November 7th, at 8:00 p.m. in the American Museum of Natural History.

The Junior Astronomy Club will meet in the American Museum on November 16th, at 8:00 p.m., when Dr. Charles P. Olivier, Flower Observatory, will speak on "Meteors."

Rutherford, N. J.: The Astronomical Society of Rutherford is scheduled to meet on Thursday, November 1st, in the Rutherford YMCA at 8:15 p.m. Alfred E. Cox will speak about "Our 15 Brightest Stars."

Washington, D. C.: The National Capital Astronomers meeting on November 3rd, at 8:15 p.m., will be held in the Department of Commerce building auditorium. Dr. Leah Allen, of Hood College, will be the guest speaker.

BOUND VOLUMES

We are closing out our stock of bound volumes at the cost price of $5.50 per volume postpaid. Only Volumes V and VI are available. These are for the years 1945-46 and 1946-47, respectively. Please remit with your order.

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NEW METEORITE CRATERS?

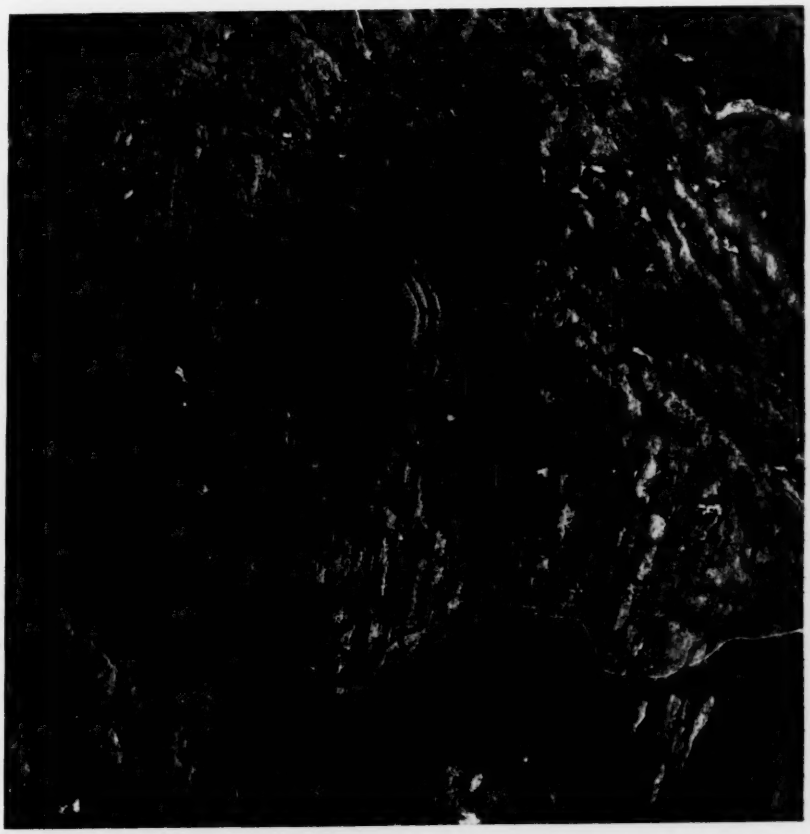
(Continued from page 2)

1,350 feet. At other points the rim is only 300 feet high. The outer slope averages a 25-degree tilt, but flattens into a broad and slightly curved top. A number of rifts pierce the rim, running radially outward, some with a depth of 200 feet. The pattern of granite rock splattered in all directions away from the center indicated to the observers that a meteoritic explosion may have been the cause. Although no sign of glaciation was found in or around the crater itself, the weathering indicates a considerable age. Dr. Meen estimated the age at between 3,000 and 15,000 years.

If the new evidence proves conclusive, the Ungava crater replaces the well-authenticated Meteor Crater in Arizona as the world's largest. The latter measures 4,150 feet in diameter and is 575 feet deep, so it is exceeded more than twice in both dimensions by the Ungava crater. Another large crater was discovered in 1947 in Western Australia near Wolf Creek (see *Sky and Telescope*, May, 1949, page 163); it is 2,700 feet in diameter and 200 feet deep, and it was established as meteoritic by the discovery of meteorites near its rim in 1949.

Another crater larger than Meteor Crater was reported this summer by scientists in the Canadian Department of Mines and Technical Surveys. Located about four miles north of Brent, Ontario, in the Algonquin Provincial Park, this formation was discovered on an aerial photograph of the Geological Survey of Canada. This feature, whatever its origin, is very old and definitely preglacial, according to Dr. Peter M. Millman, of the Dominion Observatory, who was with a party that investigated the area recently.

The Cedar Lake region is covered with glacial moraine and the original features of the circular crater have been so modified that they tell little about its origin. Dr. H. M. A. Rice, of the Geological Survey, concluded that it was not volcanic, and it seems difficult to explain the circular character by any normal processes of rock folding. One possibility is that the crater was originally formed by a large meteorite. At present there is no evidence for or against this hypothesis, and further studies are needed before any proposal for the origin of this crater can be given serious consideration.



A vertical aerial photograph, taken in May, 1951, reproduction scale about 7,500 feet to the inch, showing a portion of Cedar Lake and, to the north, the circular formation suspected of a meteoritic origin. The Canadian National Railway skirts the lake on its north side, where Brent is located. Royal Canadian Air Force photograph.

NEWS NOTES

By Dorrit Hoffleit

FIFTY RADIO STARS

Investigations of radio stars carried out by M. Ryle, F. G. Smith, and B. Elsmore at the Cavendish Laboratory, Cambridge, are reported in the *Monthly Notices* of the Royal Astronomical Society, where the positions and intensities of 50 such objects are listed. By a new interferometer technique, the positions in the most favorable cases can be determined to about five minutes of arc, and most of them are accurate to within one degree. The bulk of the investigation was carried out at a wave length of 3.7 meters, although 1.4 and 6.7 meters were also used.

This preliminary survey was restricted to the region between declination $+12°$ and $+82°$.

The apparent distribution of the 50 radio stars, covering a range of 7.3 magnitudes and showing no concentration toward the galactic plane, indicates that they must either be extragalactic or relatively nearby objects. The positions of four of the weaker radio stars appear to coincide with those of four major galaxies. These coincidences indicate that the radio radiation from distant galaxies has the same general character as the radiation in our own galaxy. The strongest radio stars, however, were not found to coincide with any recognized external system. Nor were significant correlations found with the brightest nearby stars, stars of high proper motion, novae, supernovae, planetaries, or diffuse nebulosities. While the near coincidence of a radio star with the Crab nebula had earlier been announced, even this might be purely due to chance, since no other radio star is located at the position of an outstanding supernova.

The authors conclude that radio stars represent a hitherto unobserved type of stellar body whose visible radiation is very weak, and "there is good reason for believing that they are extremely common bodies distributed throughout the galaxy." However, it has yet to be determined whether or not these objects are of stellar dimensions.

SPACE TRAVEL SYMPOSIUM

On October 12th, the Hayden Planetarium in New York City held its first annual symposium on space travel, with Willy Ley, rocket authority, as coordinator. Talks were scheduled to be given by Mr. Ley, "Thirty Years of Space Travel Research"; Robert R. Coles, chairman of the Hayden Planetarium, "The Conquest of Space"; Dr. Fred L. Whipple, Harvard College Observatory, "The Upper Atmosphere and 'Empty' Space"; Dr. Heinz Haber, department of space medicine, Randolph Field, Tex., "Space Medicine"; and Oscar Schachter, acting assistant secretary-general, legal department of the United Nations, "Legal Aspects of Space Travel."

PROBABLE JUPITER SATELLITE DISCOVERED

A telegram received at the Harvard Observatory clearinghouse on Saturday, October 6th, read:

"Object magnitude 19 probably a new satellite of Jupiter photographed by Seth B. Nicholson with 100-inch in following positions 1951 Universal time September 29.25 Object minus Jupiter right ascension plus 2 minutes declination plus 0.4 minutes arc. October 4.40 right ascension plus 2.5 minutes declination plus 7.1 minutes arc. Confirming photographs by Cunningham with 60-inch. Mount Wilson Observatory, Ira S. Bowen."

Jupiter already has 11 known satellites, three of them discovered by Dr. Nicholson. He is on the staff of the Mount Wilson Observatory; Dr. Cunningham is a member of the Berkeley astronomical department of the University of California.

If this discovery is conclusive, Dr. Nicholson will rank with Galileo as having found four of Jupiter's moons.

CAMPBELL OBSERVATORY

Years ago a prosperous automobile distributor in Puebla, Mexico, Sr. Domingo Taboada, became interested in the heavens and sent to the AAVSO some volunteer observations of variable stars. The late recorder, Leon Campbell, corresponded with the new observer, giving him valuable counsel. Now Sr. Taboada has named his private observatory in honor of Mr. Campbell. Dr. Harlow Shapley, in Mexico to receive an honorary degree on the occasion of the 400th anniversary of the National University of Mexico, unveiled the nameplate of the new Leon Campbell Observatory.

Sr. Taboada's equipment includes a 6-inch refractor and a 12-inch reflector with photographic attachments; observations may be made of stellar spectra, comets, novae, and the like.

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.
SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evening, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BOSTON: *Little Planetarium.* Boston Museum of Science, Science Park, Boston 14, Mass. Richmond 2-1410.
SCHEDULE: Tuesday through Friday, 3 and 4 p.m.; Saturday, 11 a.m., 2, 3, and 4 p.m.; Sunday, 2, 3, and 4 p.m. Spitz projector. In charge, John Patterson.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.
SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.
SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Manager, A. F. Jenzano.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.
SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 1, Mo., Chestnut 2215.
SCHEDULE: Saturday, 3:30 p.m.; Sunday, 3:00 and 5:00 p.m. Spitz projector. Director, Charles G. Wilder.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.
SCHEDULE: Wednesday and Thursday at 8:30 p.m.; Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Trafalgar 3-1300.
SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Chairman, Robert R. Coles.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.
SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.
SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Oregon Museum of Science and Industry Planetarium.* 908 N.E. Hassalo St., Portland 12, Ore., East 3807.
SCHEDULE: Saturday, Sunday, and Wednesday, 4:00 p.m.; Tuesday, Thursday, and Friday, 8:00 p.m.; Saturday show for children only, 10:30 a.m. Spitz projector. Director, Stanley H. Shirk.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.
SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.
SCHEDULE: Sunday, 4:15 p.m. Special showings on request. Admission free. Spitz projector. Director, Robert E. Cox.

The Sun Is a Peculiar Star

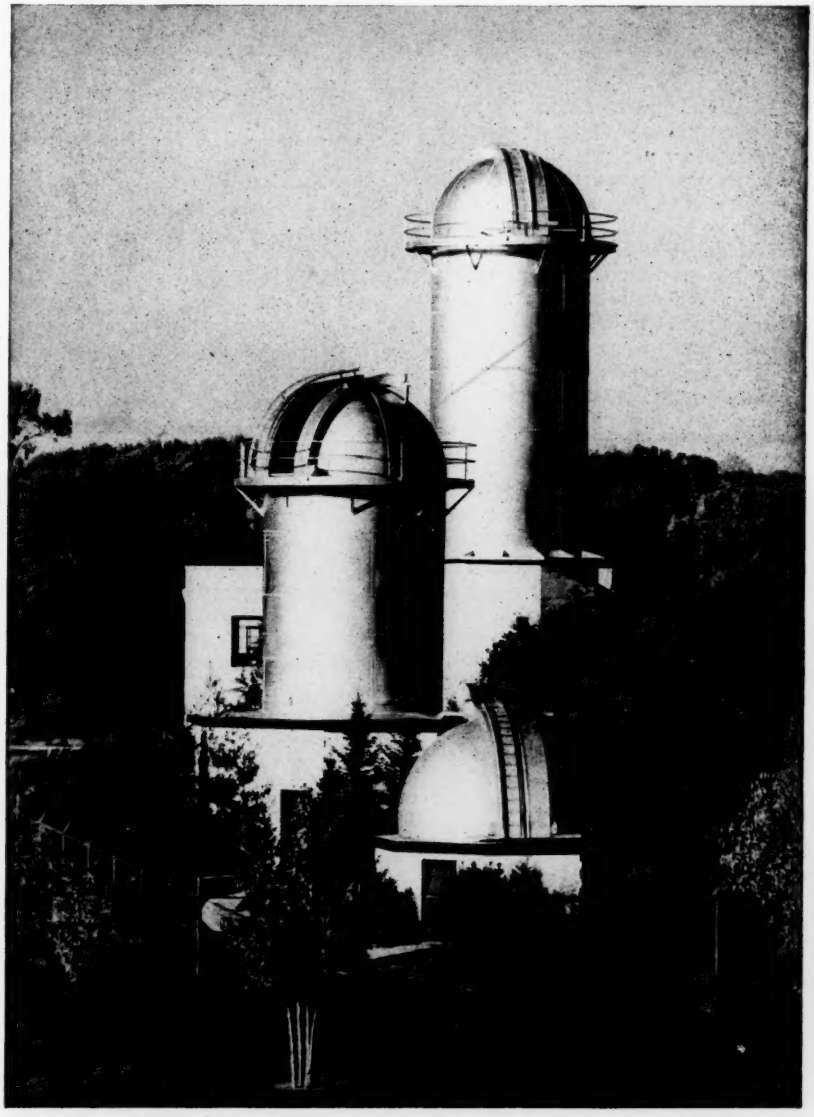
By Otto Struve, *Berkeley Astronomical Department, University of California*

THE LATEST of the misrepresentations which a few Soviet writers have recently been making against Western scientists is a short note in the *Astronomical Circular* of the Russian Academy of Sciences (No. 109, January 24, 1951), which picks out the "iron cistern" of the McMath-Hulbert Observatory of the University of Michigan as a horrible example of those Western observatories which "frequently limit themselves to satisfying solely the technical requirements of the astronomers, while the Soviet observatories are being designed and constructed with proper regard for the national architectural traditions" of the country. It is, of course, true that the McMath-Hulbert Observatory is "severely functional" in its design, as a famous American architect once remarked. But it is not true that this quiet research institution is a blot on the landscape, as one might infer from the disparaging comment I have quoted. On the contrary, considering that it is not intended to be a show place but rather a retreat for serious study and work, it is pleasing to the eye — whether or not it conforms to the traditions of former generations.

Americans are justifiably proud of the McMath-Hulbert Observatory, and they consider themselves fortunate to count within their "fraternity" one of the founders and the guiding spirit of the observatory, Dr. Robert R. McMath. It is not uncommon to find, among astronomers of many countries, persons who started their work as amateurs, and who contributed materially to the advance of the science by erecting new telescopes and observatories. But it is unusual when such an amateur becomes, in his own right, a leader of scientific thought. Dr. McMath is such a man. Almost 20 years ago he became interested in motion picture photography, and especially in its application to astronomical phenomena. The idea itself was not particularly new; it must have occurred to many others. But the technical difficulties were formidable. In order to obtain continuity it was necessary to guide the telescope accurately while the motion picture camera was taking successive exposures, and that, as every astronomer knows, is not an easy task. Would the resulting films warrant the necessary expenditure of effort and money? Most astronomers concluded that they would not. Why, indeed, should a poor observatory undertake to furnish a mildly entertaining film to the richest industry in the world, when the promise of finding new scientific facts was slim?

But Bob McMath is an "enthusiast," who at that stage of his astronomical career probably knew little of the relative values of different kinds of observational effort, and he teamed up with another amateur astronomer, Judge H. S. Hulbert. Encouraged by the wise counsel of the two Michigan astronomers, R. Curtiss and H. D. Curtis, they boldly proceeded to develop the necessary technique. The rest of the story is well known. McMath produced the first completely satisfactory electronically controlled telescope drive, a development that with some further improvements was quickly copied for the 82-inch McDonald Observatory reflector, and which has since become standard equipment in all modern telescopes. And he revolutionized the study of solar prominences in a manner no one could have foreseen. I quote from Donald H. Menzel's book, *Our Sun*: "Two enthusiastic amateurs — McMath and Hulbert — built a solar observatory equipped with mechanical and optical equipment of highest precision. The boldness of their concept, the skill of their engineering, and the high quality of their scientific results have placed this observatory at the pinnacle for general solar research."

During the past summer it was my

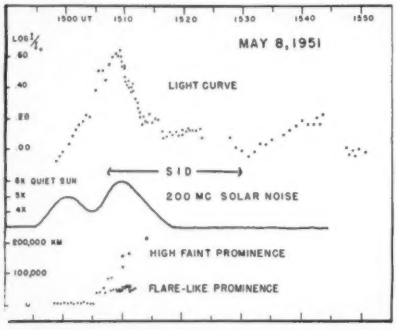


The original observatory dome of the McMath-Hulbert Observatory is dwarfed by 50-foot and 75-foot towers to the sun. All illustrations with this article are by courtesy of the University of Michigan Observatory.

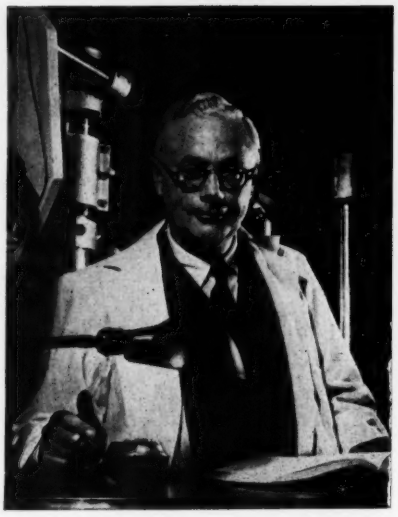
good fortune to spend a month at the University of Michigan, and to visit, on several occasions, the McMath-Hulbert Observatory at Lake Angelus. I thus had an excellent opportunity to meet the members of the observatory staff and to discuss with them those major problems of solar research with which they are at present concerned. The first impression one gets after meeting a solar physicist is of an almost impenetrable complexity of the physical phenomena on the sun. Far gone are the days when sunspots and faculae represented the sum total of our knowledge of the solar surface, and prominences could only be seen during a total eclipse of the sun!

But perhaps I should explain at this point the strange title of this article. I have spent most of my life studying the distant stars (although I must admit that at one time I served as spectroheliograph assistant to Dr. O. J. Lee at the Yerkes Observatory!), and I am in the habit of relating every new piece of information to what is known about some old friend among the stars. And thus it came about that nearly everything I learned from the McMath-Hulbert astronomers would remind me of some well-known peculiarity among the stars. The sun, in fact, combines most of the peculiar features that have been discovered in stellar astronomy, and the difference between them is one of degree, not of intrinsic quality.

Perhaps the most exciting recent result is Helen Dodson's discovery of astonishingly large outward motions in a brilliant solar flare, or eruption, which she observed at the edge of the sun on May 8th of this year. A flare is an area of great brightness which sometimes lasts for only a few minutes. Being very much brighter than the normal surface of the sun, it is presumably very hot and, as a rule, it acts as a powerful source of ultraviolet radiation which produces in the earth's atmosphere all sorts of radio fadeouts and magnetic disturbances. The lines of hydrogen are seen as luminous features in the spectrum, and their enormous widths, interpreted as a superposition of countless Doppler displacements of individual atoms, show that the gases are moving in a chaotic manner. But heretofore such motions were always regarded as internal: the atoms inside the flare were being tossed about in all directions, but the flare as a whole remained substantially at rest.



A correlation in time of the limb flare pictured on the back cover with the flare's light intensity, which reached a maximum four times as bright as the undisturbed hydrogen disk; a sudden ionospheric disturbance; noise at 200 megacycles, recorded at Cornell; and height above the solar limb of the two prominences. Chart compiled by Helen W. Dodson.



Dr. Robert R. McMath, at the observer's desk in the 50-foot tower of the McMath-Hulbert Observatory.

Dr. Dodson's observations were made with a motion picture camera that recorded the flare at 30-second intervals. A few of the individual frames are reproduced on the back cover. The flare shot up during the first 60 seconds of its life with a velocity of 700 kilometers per second — almost as fast as the gases of a nova. And it reached a height of 60,000 kilometers. During the remainder of its life it stayed at about the same height. Perhaps, says Miss Dodson, we have not previously been able to catch a flare during the single first minute when it shoots out from the surface of the sun. Incidentally, the flare of May 8th produced all the usual radio-wave effects associated with the disturbed regions of the sun; and the arrival of the first perceptible source of ionospheric disturbance coincided with the observed time of the photographic record, as shown on the accompanying chart. Hence, the source of the disturbance in our atmosphere was real light — not material particles of the kind we discussed in previous articles on the aurora.

The sun is thus clearly a *flare star*, similar in kind to the new class of variables that has received so much attention in recent years from W. J. Luyten, H. Shapley and his associates, the two Krons, and others. It is also a *radio star* — and one of variable radio emission at that.

Should we perhaps think of the solar flares as a special kind of prominence? Very likely we should. The back-cover photographs could easily be mistaken for those of a prominence, except that the surface brightness of the flare greatly surpasses those of ordinary prominences. A few of the latter can be seen on the left side of each frame in the series.

One minor difference previously believed to distinguish flares from prominences now also disappears as the result of Dr. Dodson's work. The flares are always *bright* when seen on the disk of the sun. The ordinary prominences were usually thought to be *darker* than the surrounding portions of the disk. A photograph taken by her on May 21, 1951, shows an interesting filamentary prominence that is partly projected outside the solar edge, while the rest is a well-defined *white* band on top of the grayish surrounding surface.

Of course, these solar prominences are also finding their counterparts in stellar astronomy. How else could we explain the irregular eruptive motions of hydrogen and other gases that we have recorded by means of the Doppler effect in several well-known peculiar stars? And the analogy may even be carried to the distinction between stellar prominences that are more brilliant than the undisturbed surfaces of the stars and

A McMath-Hulbert spectroheliogram made May 21, 1951, of the same region of the sun as in the May 19th series opposite. The prominence appears brighter than the disk instead of darker as is usually the case.

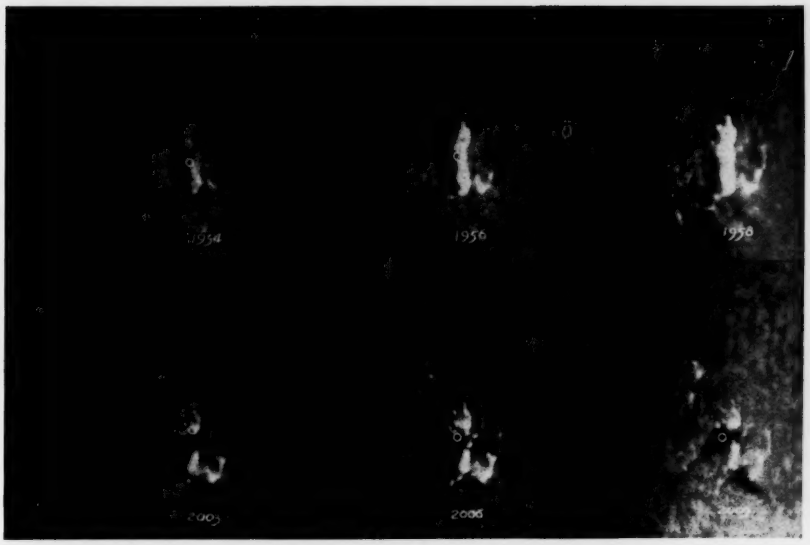
are observed as emission features and those that are darker and reveal themselves as narrow absorption lines.

An even more remarkable "peculiarity" of the sun that has a stellar analogy was recorded by Orren Mohler in the vicinity of Dr. Dodson's bright prominence. On May 19th, two days before the disturbed region of prominences and spots in her photograph had approached the sun's limb, Dr. Mohler obtained a remarkable series of spectrographic observations of a helium absorption line at wave length 1.083 microns (10,830 angstroms). This line is not visible to the human eye, which does not register infrared light of wave lengths greater than about 0.7 micron. It can be photographed only with diffi-

culty because infrared-sensitive emulsions are slow and unsatisfactory. But the McMath-Hulbert Observatory has recently acquired from R. Cashman, of Northwestern University, a photoconductive cell, in which a small amount of lead sulfide possesses the property of changing its electrical conductivity when it is illuminated by infrared light. An invisible infrared spectrum of the sun is produced with a grating or prism, and the lead-sulfide cell is slowly moved along the spectrum. Whenever it passes over a spectral absorption line the conductivity is altered, and this alteration is recorded on a moving strip of paper by means of a suitable recording apparatus. The result is a tracing of the infrared spectrum upon which the absorption lines stand out as V-shaped indentations. If a spectral line is strong, the indentation is deep and broad; if it is weak, the tracing shows only a slight downward irregularity or disturbance. The strength of the absorption line is measured by the area of the triangle that is formed by the V-shaped indentation.

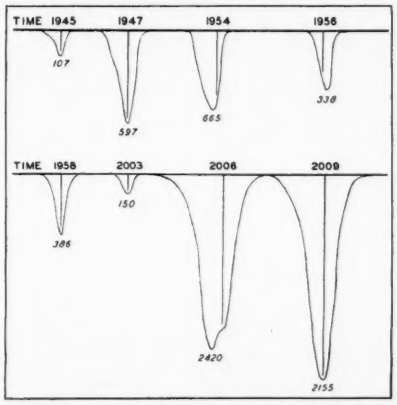
Mohler has found an amazing variation of the strength of the helium line at 1μ. On the first tracing, made at 19:45 Universal time, the area was 107 units. Twenty-one minutes later it was 2,420 units. This corresponds to a change by a factor of more than 20 — a truly astonishing result! It not only confirms earlier work by the Babcocks and others at Mount Wilson and by the two d'Azambujas at Meudon, but it greatly extends it. The helium line was strong in a disturbed region of the sun. The greatest strengthening is neither in a spot nor in a particularly brilliant facula. Instead, the line was especially strong in a moderately bright calcium flocculus or plage. Mohler remarks that in the hydrogen plages, where these are different from the calcium plages, the helium lines do not appear greatly strengthened.

Now, why should this particular line of helium, and of no other chemical element, be subject to such large and rapid variations? The ordinary Fraunhofer lines (see *Sky and Telescope*, March, 1951, page 117) vary but little from region to region, or from time to time. A tentative answer comes from Leo Goldberg and Lawrence Aller, the theoretical experts at the University of Michigan. The helium line at 1μ is rather interesting from the point of view of the structure of the helium atom. Ordinarily a line is produced (and a corresponding radiation is absorbed) when the atom swallows a photon of light and thus acquires more energy than it had before. Since at all times there are innumerable photons passing through the atmosphere of the sun, a particular helium atom may swallow a second photon before it has time to disgorge the first. Thus, there are at any moment atoms that have swallowed one, two, or more photons, in addition to those that have not yet swallowed any. The latter are, of course, the hungriest of all, and they keep gorging themselves with ultraviolet photons. This first process remains invisible to us, however, because the earth's atmosphere absorbs the ultraviolet light involved before it can reach our instruments.



In these hydrogen spectroheliograms taken at the McMath-Hulbert Observatory, May 19, 1951, the white circles show areas of helium observations made at the Universal times given by the numbers. These match the last six intensity curves plotted below.

Certain helium atoms possess more than their natural energy — they have already swallowed some photons of the appropriate kind. It turns out that there are two kinds of these gormandizing atoms. Some find it relatively easy to disgorge their photons and they thereby return to their initial state. But others cannot easily get rid of their excess energies — the particular kind of photons on which they thrive "stick in their throats." If there are many photons of this indigestible kind, there will be a tremendous accumulation of helium atoms which cannot emit their excess energy and, in desperation, can only swallow another photon, this time of wave length 1.083 microns.



The total strengths of the helium absorption line at 1.083 microns in different regions at various times between 19:45 and 20:09 UT, May 19th. The number at the foot of each curve is the equivalent width of the absorption line in milliangstroms.

According to Goldberg and Aller, the indigestible photons are available in certain parts of the sun, and in tremendous numbers in the light of the corona. This produces an increase in the number of those atoms that are in the right mood to absorb the light of 1μ wave length. Goldberg believes the overpopulation of the particular kind of helium atom that produces the line observed by Mohler can become very great, and "the balance between emission and absorption is very delicate."

All of this is a woefully inadequate effort to explain in simple terms a theory that has come to be known in astrophysics as the theory of cycles. It was first proposed by S. Rosseland from purely theoretical considerations, and was then successfully used by K. Wurm and myself to explain a strange effect of strengthening — not of Mohler's line at 1μ, which cannot as yet be observed in the stars — but of two or three other stellar helium lines which behave, in a lesser degree, like Mohler's line. The stars which show this strengthening are peculiar; they have shell spectra. The word shell stands for a tenuous ringlike structure of gas surrounding these stars; it plays the same role as does the corona in the case of the sun. Hence, there is again a remarkable corroboration of solar discoveries in the astrophysics of the stars.

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BOOKS AND THE SKY

JOHANNES KEPLER: LIFE AND LETTERS

Carola Baumgardt. Philosophical Library, New York, 1951. 198 pages. $4.75.

THE AUTHOR gives an account of the life of Kepler, using some unpublished manuscripts, and giving translations of letters which passed between Kepler and leading scientists and laymen, as well as some of the rulers of Europe. Included is some correspondence with Galileo; in one letter he asked Galileo to make some observations for him, since he had no instruments himself.

Albert Einstein says in his introduction to the book, "One can only feel grateful that the letters of this incomparable man have been made accessible to an English reading public by Mrs. Baumgardt's translation. The letters extend over a period of time from 1596 to 1631. The selection is governed, primarily, by the necessity of communicating to the reader a picture of Kepler the man as a personality; no attempt is made to bring to the foreground his scientific achievements and their unique consequences. But a reader who knows the state of science at the time can also learn something valuable, in this respect, from these letters."

All his life Kepler longed for stability and security which would allow him to concentrate on his astronomical work. But his great accomplishments, requiring much tireless work, were made in spite of continued difficulties, resulting partly from the Thirty Years' War. He continually faced poverty, never being able to persuade the various rulers who sponsored him to pay him all his promised salary, and therefore rarely being able to hire a mathematical assistant. He had great difficulty getting his works printed. He held liberal, unorthodox religious views. He was continually fighting to keep his scientific, political, religious, and financial independence. Domestic misfortunes beset him also. Almost a year of his life was spent in trying to save his mother from torture and execution when she was accused of witchcraft. One of his most moving letters was written after the death of his wife and one of his sons.

Several letters show his relations to Tycho Brahe. In one he says, "Tycho is very stingy as to communicating his observations. But I am allowed to use them daily." After Tycho's death his heirs made it difficult for Kepler to use the observations.

There are several references to astrology. Kepler indulged in some astrological prophecies in the calendars he published, but he considered astrology an inferior and questionable art, once referring to it as "the foolish little daughter of the respectable mother astronomy."

His sense of humor is revealed in a letter announcing the date of his second marriage. "The wedding will take place on the day of the eclipse of the moon when the astronomical spirit is in hiding, as I want to rejoice in the festival day."

These letters show Kepler to be not only a great scientific genius but a noble and lovable personality with a poetical and accurate imagination, enduring a life full of hardship with great spiritual strength. They show a philosophical, religious man who devoted his life to the advance of astronomy. He says, "I strive to publish [my observations] in God's honor who wishes to be recognized from the book of nature." "I had the intention of becoming a theologian . . . now see how God is, by my endeavors, also glorified in astronomy."

He comes to the defense of the study of astronomy thus: "But, pray, one will ask, what is the good of the knowledge of nature, of all astronomy, to a hungry stomach? Painters are allowed to go on with their work because they give joy to the eyes, musicians because they bring joy to the ears, though they are of no other use to us. What insensibility, what stupidity, to deny the spirit an honest pleasure but permit it to the eyes and ears! . . . Do we ask what profit the little bird hopes for in singing? We know that singing in itself is a joy to him because he was created for singing. We must not ask therefore why the human spirit takes such trouble to find out the secrets of the skies. Our creator has given us a spirit in addition to the senses, for another reason than merely to provide a living for ourselves." And again, "If there is anything that can bind the heavenly mind of man to this dusty exile of our earthly home and can reconcile us with our fate so that one can enjoy living — then it is verily the enjoyment of . . . the mathematical sciences and astronomy."

There are some minor errors to note. One rather strange translation says, "The orbits of the planets are ellipses in whose one focus the sun is situated." A typographical error on page 27 gives the date 1495 when it should be 1595.

MARJORIE WILLIAMS
Smith College Observatory

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NINTH ASTRONOMER ROYAL

Margaret Wilson. W. Heffer and Sons Ltd., Cambridge, England, 1951. 294 pages. 25s.

THIS biography of Sir Frank Watson Dyson, written by one of his daughters, portrays the life of a skilled scientific worker, a devoted father of eight children, and a man of many public and philanthropic services. Although the book does not attempt a detailed account of his astronomical work, much of it is given passing mention. And important work it was.

In the best tradition of Greenwich, Dyson labored with the astronomy of position, carefully cataloguing the positions of north polar stars. He observed six solar eclipses. He published books on both topics. Eddington considered him among the greatest of the makers of modern astronomy. Researcher, author, administrator, and organizer of international scientific bodies, his work extended far and wide. He and Eddington jointly organized the scientific expedition in 1919 that gave confirmation of the Einstein theory. He was prominent in the organization of the International Research Council (later the International Council of Scientific Unions), and in the formation of the International Astronomical Union.

To the British public Dyson was perhaps best known as the man who introduced radio time signals from Greenwich. Unobtrusively, he had his fingers in many an astronomical pie. He traveled in many lands and had numerous acquaintances among the astronomical fraternity throughout the world. International scientific co-operation was very dear to him.

The book is entertainingly written and well indexed.

RALPH S. BATES
Cambridge, Mass.

NEW BOOKS RECEIVED

THE PLANET MARS, *Gerard de Vaucouleurs*, 2nd edition, 1951, *Faber and Faber, Ltd.* 91 pages. 10s 6d.

The second British edition of the de Vaucouleurs book makes its appearance a little over a year after the first. Certain minor errors noted in the first edition have been corrected.

OBSERVING THE HEAVENS, *Peter Hood*, 1951, *Oxford*. 64 pages. $1.75.

This is the first volume in the Oxford Visual Series, annotated picture books for children from 11 to 15 years old. The book includes simple star charts, many diagrams, and an old star map in color as a frontispiece.

ASTRONOMISCHER JAHRESBERICHT, Band 46, 1951, Astronomische Rechen-Institut, Seminarienhaus, Augustinerstrasse 15, Heidelberg, Germany. 267 pages. DM 40.

This volume concludes information on the literature of the years 1943-46, the first part of which was published in Vol. 45 of the *Jahresbericht*. Vols. 47 (for 1947) and 48 (for 1948) appeared during 1950; the latter was noted in New Books Received for March, 1951.

A HISTORY OF THE THEORIES OF AETHER AND ELECTRICITY — THE CLASSICAL THEORIES, *Sir Edmund Whittaker*, 1951, *Thomas Nelson*. 434 pages. 32s 6d.

The book, discussing the classical theories from Descartes to the close of the 19th century, is a revised and enlarged edition of the author's 1910 work. A second volume is proposed which will continue the story to the present time.

PATTERNS IN THE SKY, *W. Maxwell Reed*, 1951, *Morrow*. 125 pages. $2.50.

This story of the constellations is designed for youngsters of 10 years and up. The stories of 25 constellations are told, and simple star charts are included.

COORDINATES OF THE FIVE OUTER PLANETS, 1653-2060, *Eckert, Brouwer*, and *Clemence*, 1951, Astronomical Papers, Vol. XII, Nautical Almanac Office, U. S. Naval Observatory. Available from Supt. of Documents, Washington 25, D. C. 327 pages. $3.50.

The volume contains data obtained by numerical integration on the IBM Selective Sequence Electronic Calculator, giving heliocentric co-ordinates at 40-day intervals for the outer planets. A discussion of the work involved in the execution of this project appeared in the article, "The Motions of the Five Outer Planets," by G. M. Clemence and Dirk Brouwer, *Sky and Telescope*, February, 1951.

THE NATURE OF THINGS, *Roy K. Marshall*, 1951, *Holt*. 188 pages. $2.95.

In an elementary book that ranges in its discussions from "The Insides of Atoms" to "The Expanding Universe," the author hopes to make his subject as interesting to read as it is to watch on his network television program of the same title.

THE WORLD OF COPERNICUS, *Angus Armitage*, 1951, *New American Library*. 165 pages. 35 cents.

This is a Mentor book reprint of the biography of Copernicus published in 1947 under the title, "Sun, Stand Thou Still," which was reviewed on the April, 1948, Books and the Sky page. The book now joins Gamow's *Biography of the Earth*, Jones' *Life on Other Worlds*, and the *New Handbook of the Heavens*, among other Mentor reprints in science.

200 MILES UP, *J. Gordon Vaeth*, 1951, *Ronald Press*. 207 pages. $4.50.

Subtitled "The Conquest of the Upper Air," this volume discusses the atmosphere at altitudes beyond the range of manned flights, methods and instruments for investigation, and steps that have already been made forward.

THE RESTLESS UNIVERSE, *Max Born*, 2nd ed. rev., 1951, *Dover*. 315 pages. $3.95.

Here is a revised edition of the author's account of modern physics, first published in 1936 and out of print for several years. In addition to the text, there are animated diagrams in the margins which give "motion picture" effects for some fundamental physical principles.

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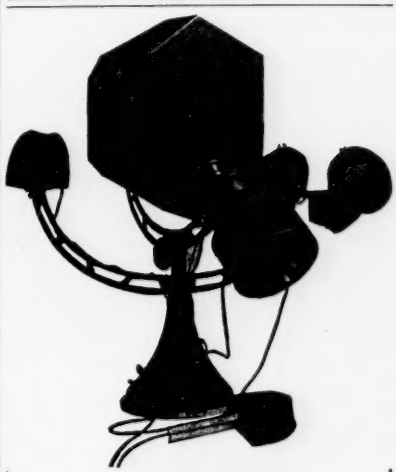

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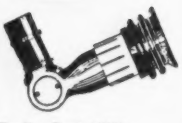

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GLEANINGS FOR ATM's

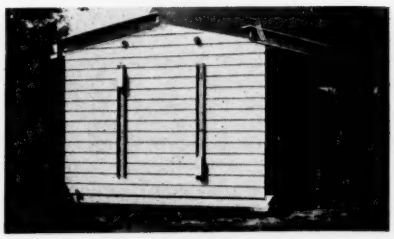
EDITED BY EARLE B. BROWN

A Small Observatory and Its 5½-inch Refractor

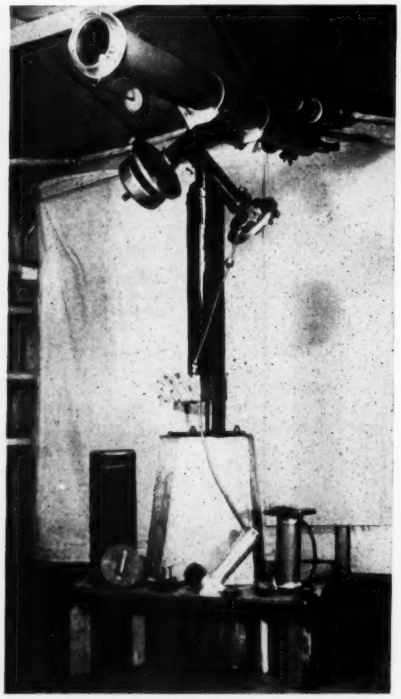
FROM an illustration in Bell's **The Telescope** I got the main idea for my slide-off roof observatory. It has the advantage of an open sky in all directions, but may suffer somewhat from wind and moonlight. However, it is relatively inexpensive to build—my layout was approximately $460, inclusive of a man's help to dig, haul material, and pour concrete.

The observatory was designed as an annex to my 18-by-22-foot workshop, and there were but three sides to be built. Heat, electricity, and machine tools were readily at hand, including a hydraulic press, drill presses, jointer-saw combination, screw-cutting lathe, and the like, without which a successful job on a telescope mounting is unthinkable. The bronze and aluminum telescope castings were leisurely machined by midnight oil while the building was going up in the daytime. Yet it took about 3½ years of spare time to complete the job.

Inside dimensions of the observatory of 10 by 11½ feet by nearly nine feet high at the ridge give ample space around the telescope in any position. The roof divides in the middle, rolling off sideways on swinging outrigger bars. Four counterweights weigh 14½ pounds each, and four sets of internal pull springs are arranged so that in opening the roof weight is increased, and in closing, diminished. The roof halves pitch 12 degrees, and are let down and pulled up by two reels from within. An air space and aluminum foil give good roof insulation.



In this exterior view, one half of the roof is opened, showing the operation of the counterweights and the swinging outrigger bars.



The manner in which Hans Pfleumer's refractor fits under the slide-off roof. Around the pier are set (left to right) the dewcap, lens cap, solar prism, wide-angle tailpiece assembly, and prime-focus camera.

The concrete pier is two feet square at the bottom, 46" below grade, tapering off to a 14½" octagon 34" above the floor. The pedestal bolts to a well-anchored ½" steel plate 13" in diameter. The building rests on four corner piers one foot square, 36" deep, to which it is anchored. Then there are two intermediate and two inner piers, all 10" by 10", 36" deep, to hold up the floor joists. The floor, therefore, has no contact with the telescope pier.

Each outer 2 x 6 roof rafter is provided near the ridgeboard with a 3" bronze roller imbedded to three fourths of its diameter and supported by steel plates and a removable shaft. The roller engages the groove in the double 2 x 4 gable rafter. The steel cable makes a right- and left-handed thread on the width of a 5" wooden spool. The one-piece cable penetrates the spool but misses the support shaft. Thereby the roof is made self-adjusting and is prevented from jamming; I have used the roof hundreds of times without a hitch.

The pedestal, weighing 125 pounds, was made of a heavy-wall 6⅛" steel tube 37" high to which top and bottom flanges were first bolted, then welded. The holes in the top flange are oblong to permit twisting the head one way or the other, and there is a screw-driven flange for rapid adjustment upon the pole in azimuth. The alignment to the instrumental pole (latitude) is by shimming, as this, to my belief, makes for more solidity. Around the pier is a U-shaped platform to facilitate the setting of the circles.

Not being a glass-pusher, I left the making of the refractor lens to the J. W. Fecker Company, who supplied a 5½-inch f/15 objective of Jena glass in a lacquered brass cell with a collimating flange. It is not coated. The mortality in lens coating requiring 1,200° F. is high, so why take a chance with an irreplaceable piece of glass? The cost of the telescope with accessories and mounting was about $766, of which the lens alone cost $420. The seeing in New Jersey is notoriously poor, but I have observed Eta Orionis (one-second separation, magnitudes 4 and 5) as double. With only fair seeing the double of Zeta Herculis was apparent

(also about one-second separation, 3.0 and 6.5).

The aluminum tube is 6″ outside diameter, ⅛″ wall. The front end is provided with an aluminum counter cell with a coarse thread to accept the dewcap, which is rolled from thin aluminum sheet and covered inside and out with black blotter. An accidental shock to it is not transferred to the lens. The lens cap can be manipulated through the dewcap. The rear end of the tube carries an aluminum ring to which a substantial aluminum casting is secured by a collimating device consisting of three push and six pull Allen cap screws. This is desirable because of the considerable weight of the several tail assemblies.

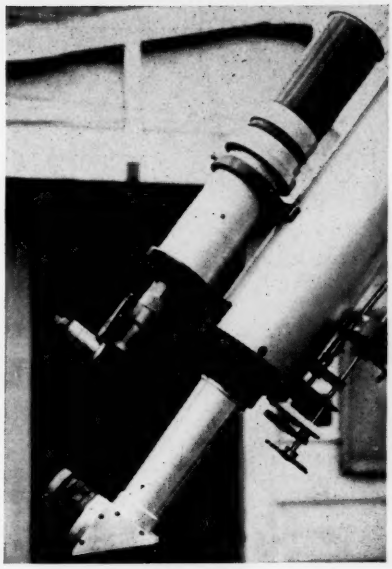
All brackets were fastened to the tube by cementing and Allen cap screws from within. The pilot-camera aluminum bracket has a female brass dovetail, slightly tapered, into which the male mate fixed to the Zeiss camera fits without wobble. The finder has a 3-inch coated achromatic lens of short focus (field of seven moon diameters); the eyepiece has a crosshair that may be illuminated by a pencil flashlight.

The disassembled view of the wide-angle tailpiece is self-explanatory. The front ring in the housing is adjustable to bring the prism into alignment; a "closed-cell rubber" pad provides the air pressure against the prism. The field lens is filled with a light cone nearly 2″ in diameter. The lenses are coated, and the field is three moons wide at 57x, its edge suffering somewhat, but such objects as the Double Cluster in Perseus are very imposing.

The store-bought rack-and-pinion motion is used most. There is an extra diagonal equipped with a Barlow lens and three eyepiece sleeves of different lengths, giving extra magnifications of 60, 80, and 100 per cent over the regular powers. The range is from 44x to 650x over all. I made one set of eyepieces, low and high power, parfocal. With the low power, one can focus upon a star which may not be in the field of the high power while looking at a diffuse object; thus I can change powers instantly without refocusing.

There are four light baffles within the tube, turned from ¼″ Bakelite plate, which did not need any fastening. The intervals between them are taken up by a cylinder of black sponge rubber serving the dual purpose of insulating against heat radiation and trapping stray light.

Design of the German-type equatorial mounting followed naturally after the selection of aircraft bearings that permit the telescope to be pushed around with a drinking straw when the clutch is disengaged. There are eight single-row ball bearings taking the thrust at about 45 degrees, two on each end of each axis. They are of 2-9/16″ outside diameter, 1-13/16″ inside diameter.

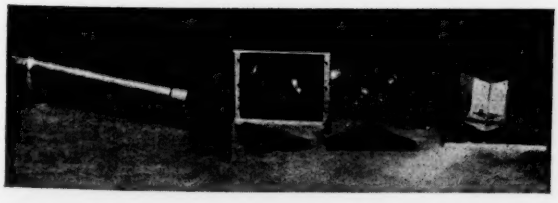


The telescope finder is fitted with a dewcap. Here the wide-angle tailpiece is in place, and the declination slow motion is engaged.

The two housings were built up from extra heavy steel tubing by welding, the Y being braced to the azimuth flange by four ribs. The altitude angle is fixed at 40½°, the local latitude. To the top end of the T a bevel gear is fixed by means of an L-shaped bronze ring, the gear forming part of the declination slow motion which is carried to the eye end. On the other end of the declination shaft housing, a double bronze arm supporting the indicator Lucite windows is fastened. Then follows a wide bronze ring, half of which protrudes and is half sawed off and split to act as a brake band around a collar on the shaft. The Y end of the T is internally threaded to receive the solid polar axis, with an integral flange to provide a normal angle with the T.

The top of the Y housing has a similar brake-band ring which clamps around the polar-axis flange. The opposite end has a single bronze arm pressed on, which not only supports the hour indicator Lucite window but also the tangential worm shaft bracket. The mesh between worm wheel and worm (80 to 1) is adjustable by a wedge between the arm and the bracket. The worm shaft runs on enclosed ball bearings.

After the polar axis is entered in the housing the following items go onto it in this order: the right-ascension slow-motion arm—fast to the axis—which carries the pinion shaft in an eccentric bushing. The pinion on one end of the shaft with a hand knob on the other can be disengaged. The knob is provided with an



The wide-angle tailpiece is here disassembled. Next to the prism is a penny, to provide scale to the picture.

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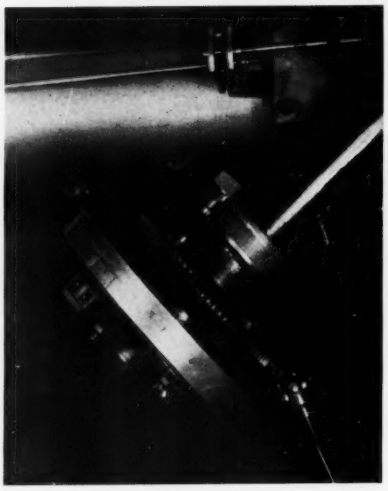

Alongside the tube the intermediate reduction of the declination slow motion is shown here. The lower polar-axis assembly is (right to left): worm arm, slow-motion arm, worm wheel assembly, hour circle clamp, hour circle, polar-axis clutch, right-ascension arm, and end cap.

internal hex to adapt a flexible shaft. The pinion shaft can be clamped down by a clutch-like device. Then follows the worm wheel having the slow-motion spur gear concentrically integrated to the inside. The worm wheel floats on the shaft; outwardly it has a hub. The hour circle follows. It has a bushing overlapping the worm wheel hub and floats on axis and hub. However, the extruding part of this bushing is made contractible by longitudinal slots, and can be clamped by a brake band against the hub, thereby making circle and worm wheel a unit floating on the shaft.

Thereupon follows the double right-ascension indicator bronze arm (fast to the shaft). Each end has a Lucite window carrying the engraved vernier underneath, close to the circle face. Then there are two underslung flat steel springs fast to this double arm. The ends are padded to clutch the circle area. By a double hook strip and wedge each clutch is disengaged. Finally, there is a washer and cap screw, to hold everything up while making adjustment of the hour indicator arm. From this the action is clear. The telescope can be moved to any right ascension without interfering with the clock.

According to the **American Ephemeris** a sidereal day has 86,164.09054 seconds. The following combination of gears will give a reduction from one revolution per minute to 86,163.93443 seconds, leaving a residual of about 1/6 second in 24 hours: 80/1 x 15/1 x 73/61. This is the best that can be done with six gears; it does not correct for atmospheric refraction. The 80 to 1 reduction is with the worm and wheel already described. The rest of the clock, including a Bodine synchronous motor, condenser, switch, and BX receptacle, is mounted at the foot of the pedestal in a heavy aluminum box. The motor has a 3/16" shaft, and mounting the worm and worm wheel (15 to 1) is delicate. At the bottom are the two correcting spur gears (73 to 61). The four shaft ends move on enclosed ball bearings with a thrust bearing ball on the outside of the box for the worm wheel shaft. The resulting speed of this unit is one revolution in 17.9508 minutes, theoretically. The gears can all be bought from Boston Gear Works.

Between this gear box and the right-ascension drive worm the connection is with rods and universal joints. The law concerning a Hooke's joint is: The angular velocity of the driven shaft varies during each revolution from a maximum value of **A**/cos **a** to a minimum value **A** cos a, where **A** is the angular velocity of the driving shaft and **a** the angle between the shafts. Evidently, the remedy lies in two universals of equal angle, with the pins so situated that one error is canceled out by the opposite error; furthermore, the universal joint angles must lie in the same plane. In my case the upper universal points too far north, and a correction had to be applied empirically by using a variable coupling, shown in the picture. It is made up of two flanges, one having 12, the other 10 holes. This allows 60 different positions at six-degree intervals. My 10" hour circle can be read by means of the vernier to 20 seconds of time, and with a magnifier five seconds may be estimated. In 30 minutes this adjustment was made close enough, with the aid of a stop watch.

A long, soft pull spring between the right-ascension clamp handle and a pedestal nut holds the telescope eastward to take out the unavoidable play in the polar-axis worm and wheel.

The declination circle (11") is fast to the solid declination shaft, has 720 divisions, and can be read with the vernier to five minutes of arc. The declination shaft has an extension of 1" threaded brass rod upon which the counterweight, a 48½-pound steel gear blank, can be adjusted.

The circles and saddle are of solid ST aluminum plate, all parts machined as twins where necessary, as in the clamp-ring castings. Under the saddle plate, the declination slow motion shaft extends through a universal joint to beyond the saddle, where it connects with a second reduction in an open, slideable gear box. Then it continues through a second universal to a third reduction at the eye end. This arrangement was necessary in order to clear the hour circle when swinging the instrument over it.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

VISUAL OBSERVING PROGRAMS FOR AMATEURS — XX

Observing the Moon and Planets—(cont.)

Mars. Drawings of Mars should be made rather regularly at times of its opposition, since about 40 days are required for the features on Mars to "slip backward" so that they are again visible in their original positions on the disk. A drawing should be completed in about 15 minutes or less because of the rotation of Mars, which takes about 24 hours 37.4 minutes. Mr. Haas has kindly agreed to review such drawings as are submitted to him by beginners, in case they show any unusual features which may not be apparent to the novice himself. Notes on the colors and darkness of the maria are of value. This data may be shown on the sketch or a list can be made of the objects seen in the decreasing order of their brightness.

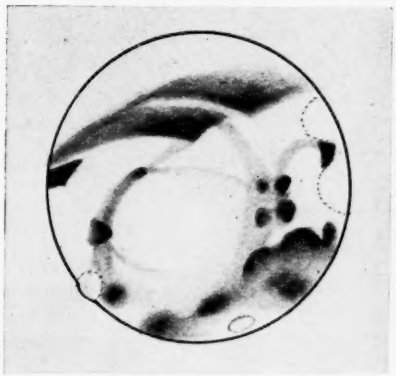
Close attention should be given to temporary bright areas with lives up to a few days in length. These are presumably clouds. The sketch made should show the area covered, and if you have a set of color filters you can test for color. A yellow cloud will remain bright if viewed through a yellow filter, whereas if it is blue in shade it will appear relatively darker through a yellow filter. If the filter is blue these effects will be reversed. In general, clouds in the temperate and tropic zones of Mars seem yellowish and are perhaps caused by dust, while the vapor clouds that form over the polar region in Martian autumns are bluish. Meridian transits (see Jupiter section) of the cloud markings may be used to determine their longitudes with regard to some well-known object such as Syrtis Major, from which their actual Martian longitudes can be computed.

If any clouds are seen projecting above the edge of the disk, these should be observed carefully and every effort should be made to recover the projection the next night. The time may not necessarily be exactly 24 hours 37.4 minutes later because the cloud may have drifted somewhat over Mars. Indeed, the aim of such observations should be to determine the amount of this drift, and thereby the velocity of the movement of Mars' atmosphere. Clouds that project from the edge of Mars are very rare; they furnish an opportunity for extremely valuable observations. However, it is not easy to differentiate between clouds which really project and irradiation effects of bright areas at the edge of the disk.

Venus. As Venus is very bright and such details as have been seen on it seem to be big blotches, small instruments can be used to advantage. The planet should be observed in full daylight or near sunrise or sunset. Setting circles are very helpful in locating its position from data given in the **American Ephemeris.**

The period of rotation is still undetermined, so drawings should be made if any markings are seen.

At greatest elongation, some 72 days before and after inferior conjunction, Venus should be watched carefully and the time when exactly half of the disk, regarded as circular, is illuminated should be noted. This phenomenon is called **dichotomy,** and the observation will help to determine the extent of the Venusian atmosphere. Obviously, if twilight extends some little way beyond the terminator, dichotomy will be somewhat delayed when Venus is in the evening sky and somewhat advanced when it is in the morning sky.



A drawing of Mars by Tsuneo Saheki, March 23, 1950, 13:25 UT, through a 20-centimeter reflector at 400 power, seeing fair. The disk diameter was 14".37, the Martian date June 36, and the central meridian 244°. Note the projecting cloud on the northern sunset limb. Reproduced courtesy Association of Lunar and Planetary Observers.

The time when the terminator is exactly straight should also be recorded, for this does not necessarily occur at the same time as dichotomy. A filar position micrometer would be helpful in such work.

For about 20 days before and after inferior conjunction, be on the alert for any great elongations of the horns of the crescent, and if they are seen make an estimate of how many degrees they project beyond the central meridian around the dark sphere of the planet. Such observations also bear upon the problem of the atmosphere of Venus.

Mercury. This planet should be observed before sunset or after sunrise, for when it is visible to the unaided eye in the twilight it is too low in the sky for steady seeing. As with Venus, setting circles are very useful in locating Mercury in the daytime sky. Mercury's period of rotation is believed to be the same as the time of its revolution around the sun. Hence, sketches made each day may well be devoted to the possible variations in such markings as are seen. As Mercury has a large libration in longitude, its appearances at different elongations will differ somewhat. The other questions regarding Mercury are similar to those outlined above for Venus, and the observing procedure should be similar.

Uranus, Neptune, and the Asteroids. Although surface details on Uranus are perhaps within the range of the larger and

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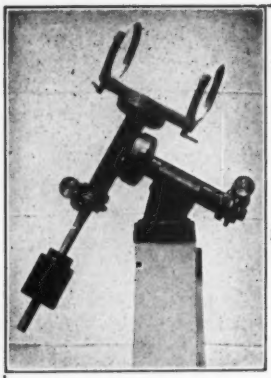

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better amateur instruments, the only program suggested on these bodies is related to their periods of rotation. Suppose one of these objects has a large dark area on it roughly corresponding to Syrtis Major on Mars. The planet's total brightness may decrease somewhat when this dark area faces us, once for each rotation on its axis. Two such dark areas, not equally spaced in longitude, could also reveal a rotation period.

There are times when Uranus presents its pole toward the earth and the above interpretation breaks down. But for Uranus, this period was passed about 1945 and will not occur again until about 1987. Asteroids, however, may also have axes that sometimes point toward us, so the determination of their rotations from fluctuations in brightness is complicated.

Although the foregoing principles are simple, the actual observations are not. The general procedure is the same as that used in estimating the brightness of a variable star. Unless the planet or planetoid is passing through a field of stars whose magnitudes are known, the comparison stars must be chosen arbitrarily and used as long as the object remains near them. They should be checked against each other for possible variation of one or more of them, in which case one suspected of variation should be discarded and others selected in its place. A brightness scale can be set up according to the observer's best judgment, and it is of little consequence whether or not these magnitudes are correct. Changes in brightness of planet or asteroid are to be found, not actual apparent magnitudes.

A useful publication for regions along the ecliptic is the **Catalog of 3,539 Zodiacal Stars for the Equinox 1950.0,** published by the U. S. Nautical Almanac Office.

Plot your observations on a time-magnitude graph, and if there is any variation it may become apparent; perhaps even a period can be deduced. However, it may be necessary to make observations extending throughout the night, and extreme accuracy in one's estimates is required because the fluctuations in brightness are not likely to be more than one or two tenths of a magnitude. I fancied that by this method I detected a rotational effect on the brightness of the asteroid Amphitrite at its opposition of 1937-38, but the work was difficult and uncertain.

Uranus is believed to rotate in a period of about 10¾ hours, based in part upon the work of the late Leon Campbell in 1917 using the method outlined above. This agrees with spectroscopic evidence. We use for Neptune a period of nearly 16 hours. It is possible that this latter planet does not present any distinct surface markings, but some astronomers are of the opinion that checks of Neptune's brightness are well worth the effort.

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UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

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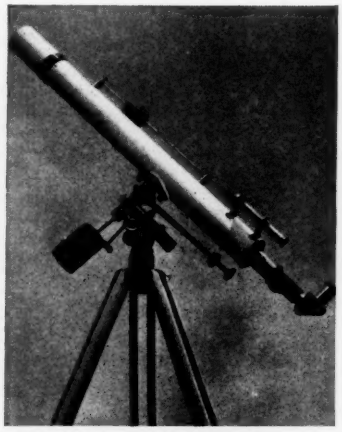

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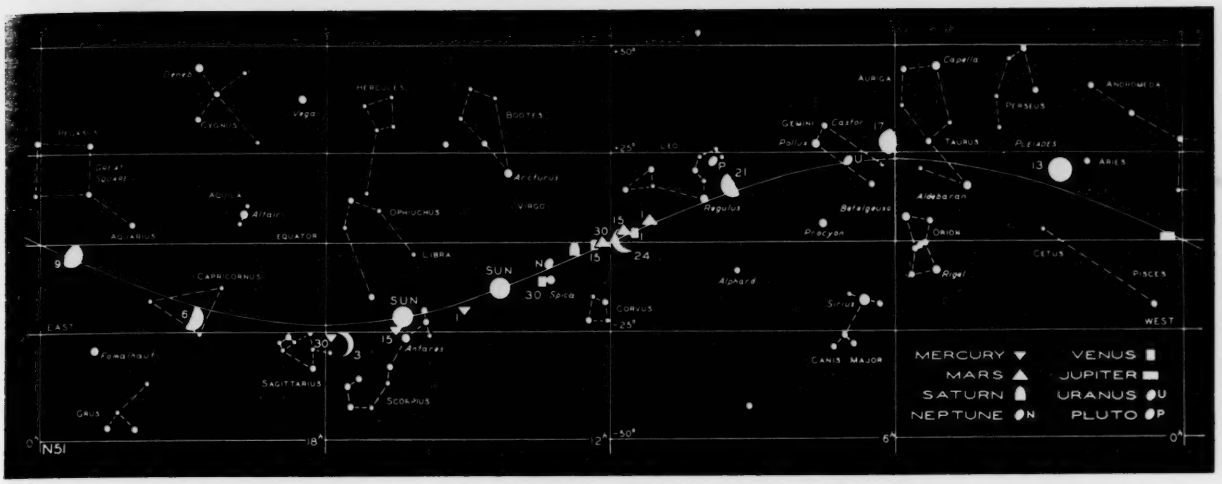

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury, found in the evening sky, attains greatest elongation on November 28th, 21° 40′ east of the sun, but this is not a favorable apparition.

Venus appears on the eastern horizon four hours before sunrise as a dazzling white object. Western elongation is reached on November 14th, 46° 39′ from the sun in longitude. At that time the disk of Venus is half illuminated and 24″ in diameter.

Mars, just under 1st magnitude in brightness, continues to separate from the sun in the morning sky. It rapidly approaches Saturn as it travels through eastern Leo and Virgo.

Jupiter, on the meridian in mid-evening, is in a fine position for observation. On November 21st, Jupiter is at its perihelion. It appears to move westward in Pisces until November 30th. Its equatorial diameter of 47″ makes this planet an excellent object for even small instruments.

Saturn, in the morning sky, is a 1st-magnitude object. Faster-moving Venus passes 38′ south of Saturn on the 21st at 10^h UT. Mars will be about 12° west of the pair at the time. Telescopically, Saturn's rings are now opening, the north face being visible and inclined to the line of sight 8°.2 on November 15th.

Uranus, in central Gemini, rises several hours after sunset. It is easily viewed with opera glasses, moving slowly westward approximately 2° north of Zeta Geminorum.

Neptune is too near the sun to be easily seen this month. E. O.

PREDICTIONS OF BRIGHT ASTEROID POSITIONS

Eunomia, 15, 8.0. Nov. 30, 6:53.3 +31-24. Dec. 10, 6:44.7 +30-59; 20, 6:33.7 +30-22; 30, 6:22.0 +29-34. Jan. 9, 6:11.0 +28-37; 19, 6:02.2 +27-33.

After the asteroid's name is its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1951.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

VARIABLE STAR MAXIMA

November 12, R Draconis, 7.6, 163266; 12, T Normae, 7.4, 153654; 13, RU Sagittarii, 7.2, 195142; 13, R Carinae, 4.6, 092962; 17, RR Scorpii, 6.0, 165030a; 21, Chi Cygni, 5.3, 194632; 27, V Cassiopeiae, 7.9, 230759; 29, RS Cygni, 7.4, 200938.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

OCCULTATION PREDICTIONS

November 6-7 **Gamma Capricorni** 3.8, 21:37.4 −16-53.1, 7, Im: **A** 20:02.5 −1.2 +0.9 111. Em: **A** 20:51.8 −1.0 +2.2 197.

November 21-22 **Rho Leonis** 3.8, 10:30.2 +9-33.6, 22, Im: **F** 7:44.5 −0.3 +2.3 70. Em: **F** 8:32.3 −0.7 −2.2 342.

November 24-25 **Psi Virginis** 4.9, 12:51.8 −9-16.4, 25, Im: **C** 10:29.2 −1.5 +1.5 86; **E** 10:16.8 −0.6 +0.9 101. Em: **C** 11:21.4 −0.1 −1.8 349; **D** 11:11.7 +0.5 −2.7 4; **E** 11:15.7 −0.4 −0.7 328.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the American Ephemeris and the British Nautical Almanac are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, a and b quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. Lo, lat. L) within 200 or 300 miles of a standard station (long. LoS, lat. LS). Multiply a by the difference in longitude (Lo — LoS), and multiply b by the difference in latitude (L — LS), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5, +42°.5	**E**	+91°.0, +40°.0
B	+73°.6, +45°.6	**F**	+98°.0, +31°.0
C	+77°.1, +38°.9	**G**	+114°.0, +50°.9
D	+79°.4, +43°.7	**H**	+120°.0, +36°.0
		I	+123°.1, +49°.5

MOON PHASES AND DISTANCE

First quarter	November	6, 6:59
Full moon	November	13, 15:52
Last quarter	November	21, 20:01
New moon	November	29, 1:00
First quarter	December	5, 16:20

	November		Distance	Diameter
Perigee	2,	13^h	227,200 mi.	32′ 41″
Apogee	18,	13^h	251,900 mi.	29′ 29″
Perigee	30,	13^h	223,900 mi.	33′ 10″

MINIMA OF ALGOL

November 3, 18:47; 6, 15:36; 9, 12:25; 12, 9:14; 15, 6:03; 18, 2:52; 20, 23:41; 23, 20:30; 26, 17:19; 29, 14:08. December 2, 10:57; 5, 7:46; 8, 4:35.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See **Sky and Telescope,** Vol. VII, page 260, August, 1948, for further explanation.

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PENUMBRAL ECLIPSES OBSERVED

THE three lunar eclipses this year were only penumbral. In my note on page 271 of the September issue it was stated that there were four of them, but February 21st should be omitted (magnitude −1.11), since for that date and time a magnitude algebraically greater than −1.047 was required for a penumbral eclipse to occur. For observers in the Middle West, the moon was above the horizon for at least part of each of the other penumbral eclipses, on March 23rd, August 17th, and September 15th.

The March 23rd eclipse was first observed visually by the writer as a slight darkening of the north limb of the moon at 9:25 UT, when the eclipse magnitude was −0.63, one hour and 12 minutes before maximum eclipse (magnitude −0.38). This does not agree with the caption for the photograph reproduced with the September article, and I believe this should state that the darkening **could** be observed visually. The final phase of the eclipse was unfortunately obscured by clouds in my vicinity.

During the August 17th eclipse, the moon was carefully watched under ideal weather conditions, but no change could be detected on the north limb, maximum eclipse magnitude being only −0.85.

The September 15th eclipse on the south limb was first detected by naked eye at 10:58 UT, when the moon did not appear as bright as normal for a full moon. The eclipse magnitude at that time was −0.57. At 11:24 and 11:34, it was estimated that 1/5 and 1/4, respectively, of the moon's diameter was darkened. These estimates place the limit of the visible darkening at magnitudes −0.576 and −0.567, respectively, agreeing well with observations at other penumbral lunar eclipses. Clouds and moonset prevented observation nearer maximum eclipse (magnitude −0.17).

Observations of these eclipses over the past 15 years show that, although the south limb of the moon is normally brighter than the north limb, eclipses of the south limb (average visual limit −0.585) have not been detected at significantly lower eclipse magnitudes than those of the north limb (average visual limit −0.58).

EDWARD M. BROOKS
Institute of Technology
St. Louis University

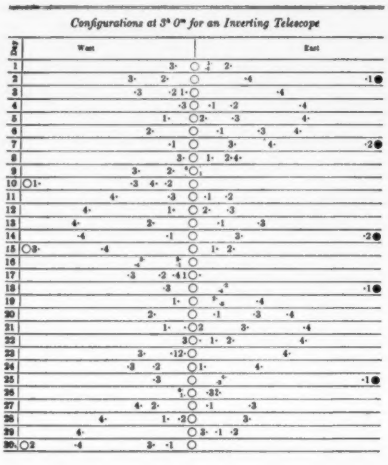
NOVEMBER METEORS

Two meteor showers take place this month, neither of special interest. The Taurids, appearing from a diffuse radiant 10° south of the Pleiades, with a predicted rate of six per hour, reach maximum from November 3rd to 10th, with limits from October 26th to November 22nd. The radiant is high in the eastern sky during the evening, with slower meteors prevalent in the shower.

The famous Leonids, no longer a feature shower, will be at a disadvantage this year, for full moon occurs on the date of the maximum, November 13th. Thus, these faint, swift meteors are hardly worth special watching, considering the predicted rate of six per hour were conditions favorable. E. O.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the Universal time given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the American Ephemeris and Nautical Almanac.



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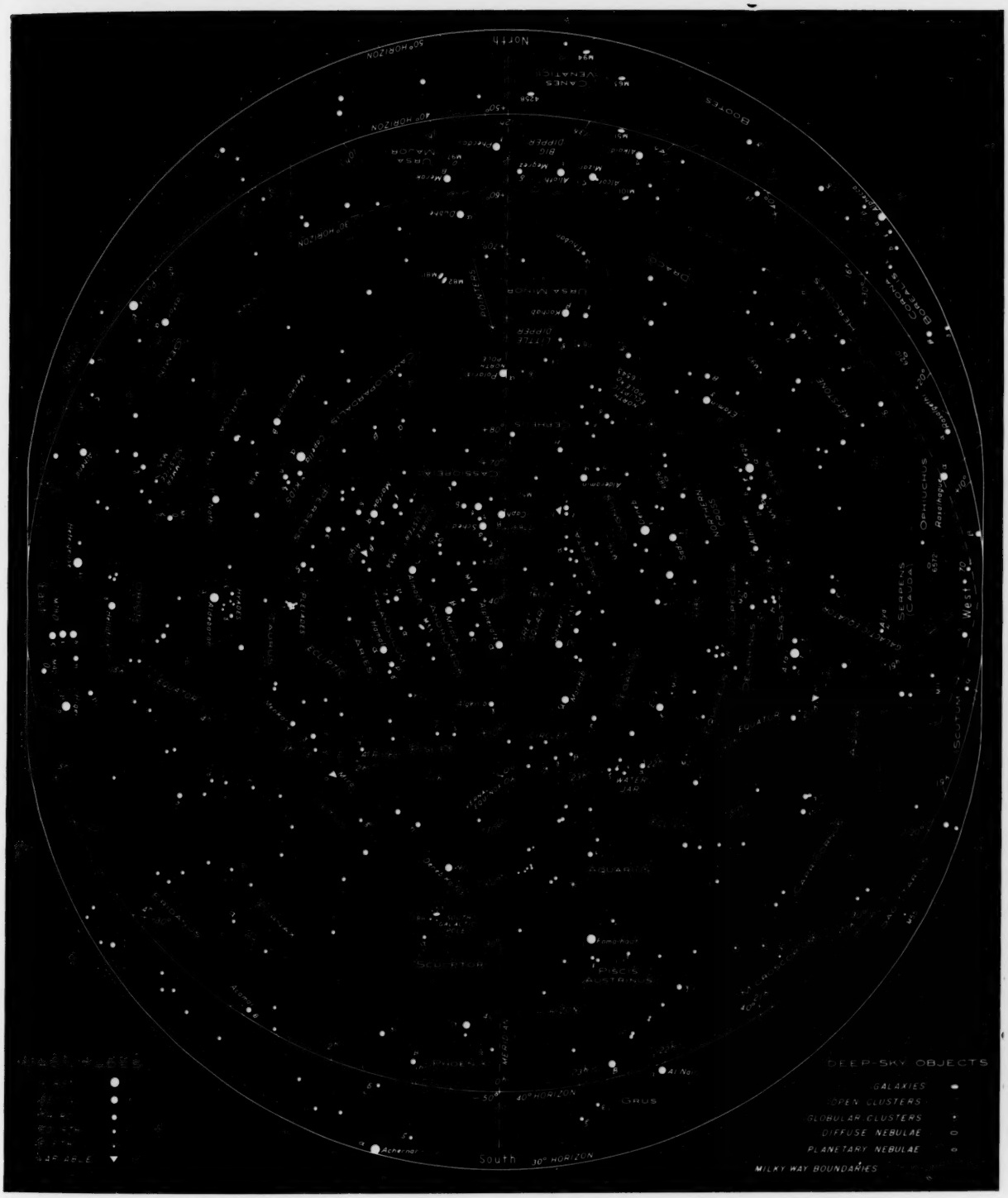

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of November, respectively.

STARS FOR NOVEMBER

TEST OBJECTS are usually thought of in connection with telescopes but many amateur observers, surveying the dome of the sky on a resplendent night, have certain tests they habitually make to determine how transparent the atmosphere actually may be.

One of these test objects is the globular cluster in Hercules, M13, which these evenings is in the northwestern sky. Usually difficult to detect, it sometimes can be seen without effort, two thirds of the way from Zeta to Eta Herculis, on the western side of the Keystone.

Another test is the appearance of M31, the great galaxy in Andromeda that may be seen from city streets, particularly this month, as it passes overhead at the latitude of New York City. When its considerable elongation and greater central brightness are evident to the unaided eye, then the night is indeed a good one.

A third test is the Double Cluster in Perseus. Even when the Milky Way is visible, the clusters may be indefinite, but under good conditions they stand out noticeably. The clusters in Auriga, and M35 in Gemini, are other tests. All of these objects, of course, are fine for study with binoculars.
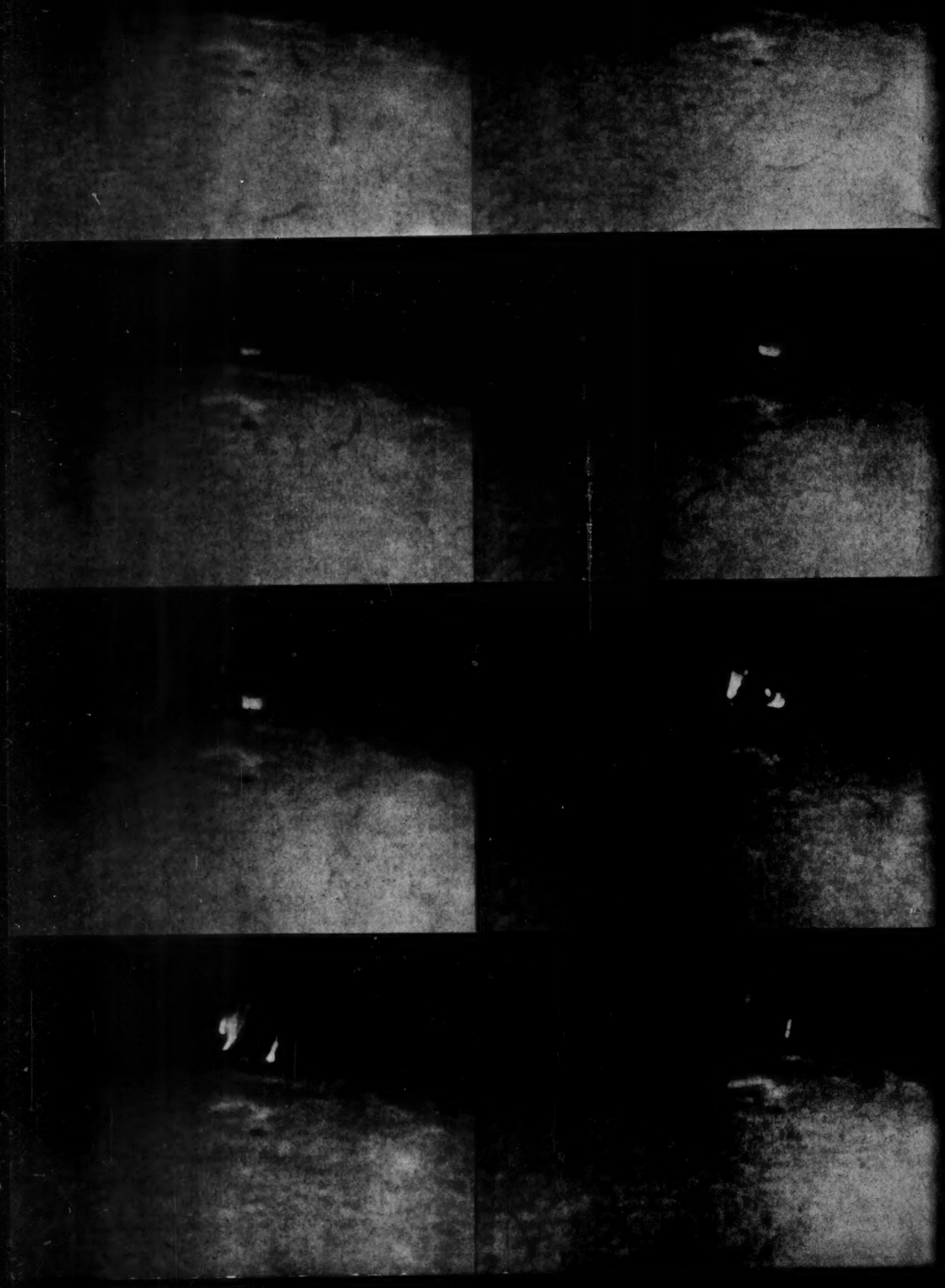
Chart Correction: The Greek letters for β and γ Lyrae should be exchanged.